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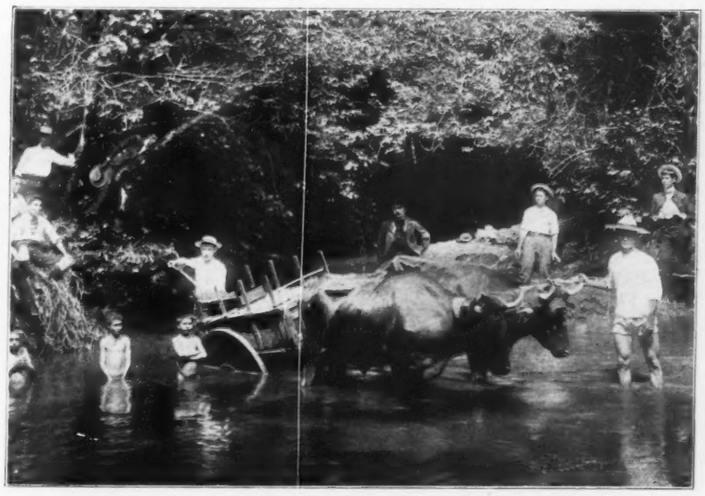
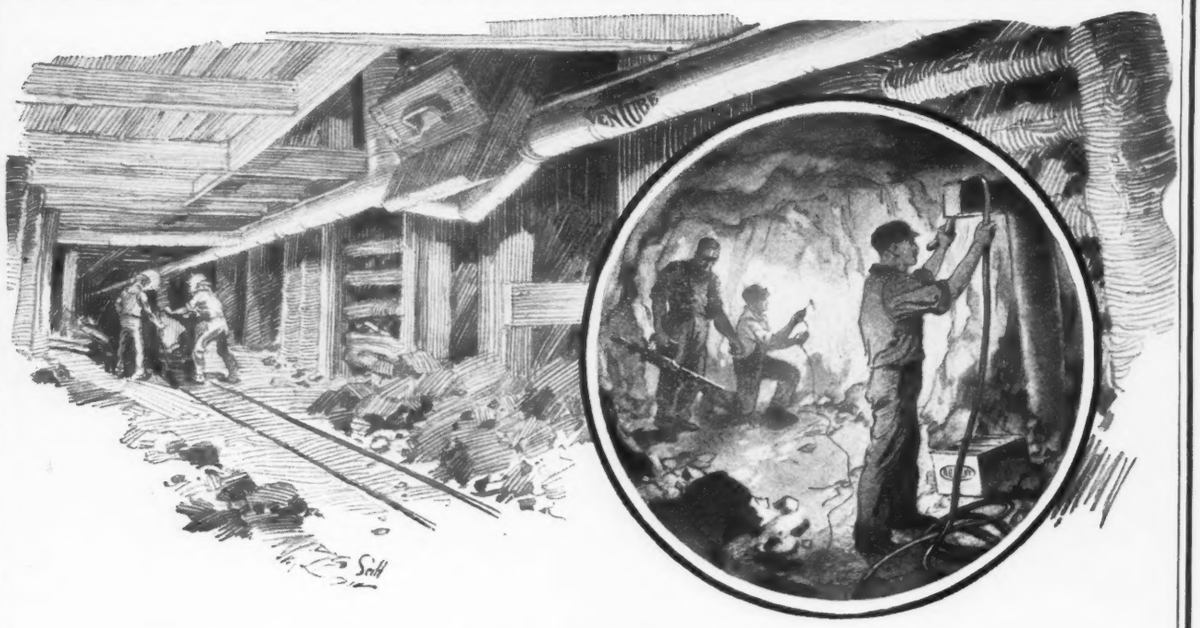


TRANSPORTATION IN COSTA RICA

OCTOBER, 1922

VOL. III MASSACHUSETTS INSTITUTE OF TECHNOLOGY NO. 4



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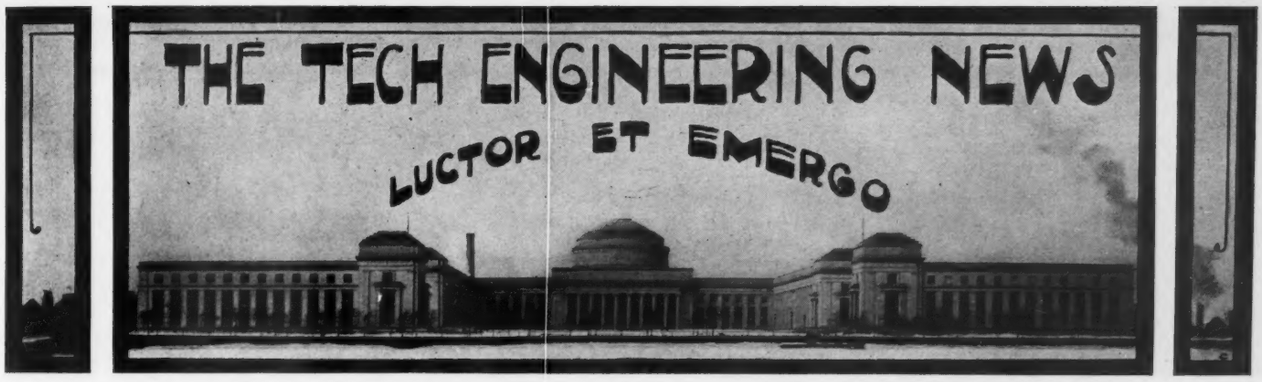

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE ALUMNI AND UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME III | OCTOBER, 1922 | NUMBER 4

LUBRICATION[1, 2]

By PROF. ROBERT E. WILSON
Director of Research Laboratory of Applied Chemistry
and
DANIEL P. BARNARD, 4th, '20
Research Associate, Massachusetts Institute of Technology

The great bulk of the mechanical energy produced by our annual consumption of 550,000,000 tons* of coal and 4,500,000,000† gallons of gasoline is dissipated in the form of friction between the moving parts of our engines, machines, or cars. It is difficult to overestimate, therefore, the enormous cost of friction, and the desirability of reducing it to a minimum.

By far the most effective method of reducing friction is by separating all moving parts by a fluid film of some "lubricant." Not only does this make a tremendous reduction in the coefficients of friction, but lubricants have the further important action of practically eliminating the wear of the metal surfaces, and greatly reducing noise.

In spite, however, of the recognized advantages and possibilities of lubrication, the average bearing probably wastes several times as much power, and produces much more abrasion, than is really necessary for a particular set of operating conditions. This state of affairs is largely due to insufficient knowledge of, or attention to, the fundamental laws of lubrication and their application to bearing design and the selection of suitable lubricants.

It must be admitted, however, that a survey of most of the existing literature on the subject tends to lead to mental indigestion, and does not make clear the essential facts needed by the designer or engineer.

One of the great causes of confusion in studying the data and conclusions of many writers is their failure to distinguish clearly between the two regions of partial and complete lubrication. To illustrate the need of such distinctions it may be pointed out that the effect of increasing either

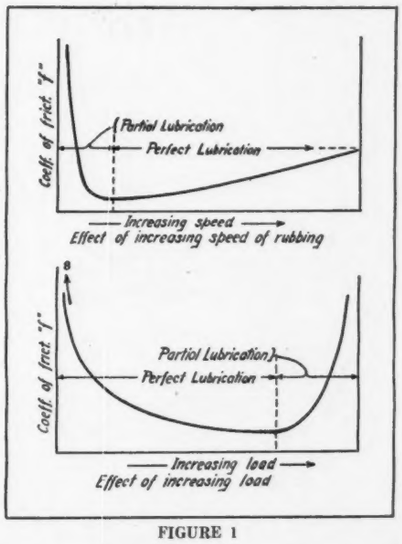

FIGURE 1

speed or load on the coefficient of friction is exactly the opposite in the two regions, as is indicated in Fig. 1.

The difference between the two types of lubrication may be most clearly seen by considering what happens when a journal bearing is started from rest. If the loading is vertical at the start the journal is resting on the bottom of the bearing, while the clearing space is filled with oil. After any appreciable period of rest all the fluid lubricant must have been squeezed out. It is an observed fact, however, that the force required to start motion is invariably somewhat smaller if some lubricant has been present than if the surfaces were dry, indicating that some material, probably a tenaciously adsorbed film of some constituent in the lubricant, had remained to partially separate the metallic surfaces. Under such conditions, however, the coefficient of friction* is still very high (around 0.15) and considerable abrasion is likely to take place, indicating that this adsorbed film is not sufficient to prevent contact, at least between the high points of the metal surface, and that the degree of lubrication is far less than that in perfect fluid film lubrication at higher speeds.

As the speed of rotation is increased a race begins between the forces which tend to build up a fluid film and those which tend to destroy it. The journal is covered with a thick film of oil at its point of maximum clearance, and its rotation tends to carry the film in between the surfaces at the point where they are in contact. The opposing force is that of the load on the bearing which creates a zone of high pressure around the point of minimum clearance, and thus tends to keep the film thinned out. Any increase in the speed of rotation or in the viscosity of the lubricant, or any decrease in the bearing pressure, will facilitate the formation of the film. The effect of the variables may be combined by saying that, if n = the R.P.M. of the bearing, z = the viscosity of the lubricant at the working temperatures (in centipoises, = relative to water at 68°F), and p = the pressure on the bearing (in pounds per square inch of projected area), any increase in the product $\frac{zn}{p}$, however produced, will give a thicker film of lubricant between the journal and the bearing.

As long as there is any metallic contact or abrasion of the surfaces,

[1] Published as Contribution No. 53 from the Research Laboratory of Applied Chemistry, Massachusetts Institute of Technology.

[2] For a much fuller discussion of this important subject the reader is referred to two articles by the authors which appeared in the Journal of the Society of Automotive Engineers for July and August, 1922

* Consumption in U. S. in 1920.

† Consumption in 1921 in U. S. alone

* The tangential force which must be applied at the bearing surface to cause motion at a given speed, divided by the load on the bearing.

(*Continued on page 118*)

THE NEW TECHNOLOGY

By F. J. WHITING
Editor, The Stone & Webster Journal, Boston, Mass.

The buildings constituting the "New Technology" are so arranged and constructed as to betoken both academic repose and a fine adjustment of means to ends. The scheme is quite different from that of most other educational institutions. There is, in the first place, no quadrangular effect. The site does not lend itself to that. The buildings are spread over about fifteen hundred feet along the Charles River Basin, fronting which is the principal façade of each. The lot on which they are erected has also that depth.

The buildings are arranged about two axial lines instead of one. The educational group is upon the western axis and the group comprising the Commons, Walker Memorial, Club House, Gymnasium and Athletic Field upon the eastern. The striking thing about the educational group is that twelve practically independent buildings are harmoniously joined into a single great structure. This is well adapted to the restrictions imposed by the site. Furthermore, it is so arranged that it may be extended to twice the initial capacity without in any measure confusing the general plan. As a matter of fact, there has already been a notable addition, which will be described later on.

The grounds are bounded on the west by Massachusetts Avenue, leading to Harvard Bridge, only a few feet away. One crossing the bridge from Boston to Cambridge thus obtains an impressive view of the "New Technology," and in particular of the educational group with its great central court, from which to east and west open out secondary or minor courts. The great court is dominated by a dome which rises above a colonnaded portico.

The unified character of the educational group, which is emphasized by the great central dome, was dictated by the need of getting to and fro between the offices, class rooms, laboratories, libraries and other departments as conveniently as possible. The great court is 360 feet square, and each of the minor courts is 165 feet. By this arrangement the maximum amount of light and air is obtained, and also the easiest and quickest access to all parts of the educational group. The buildings comprising this group are three and four stories. The floor area is 18 acres. The buildings are of reinforced concrete. The exterior walls facing the courts and the streets are limestone, except for a low granite base course at the ground level. The other walls are buff brick, with limestone trimmings. The floor finishes are marble and granite aggregate with polished surfaces. The partitions are plastered gypsum block.

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The main entrance, with its portico of large fluted Ionic limestone columns is surmounted by a reinforced concrete dome, which is 180 feet high, and is surfaced with limestone.

The following figures afford some idea of the magnitude of the structure: 25,000 wood piles, 465 loads of limestone, 5,000,000 brick, 80,000 bags of cement, 5,000 tons of reinforcing steel.

The reading room of the library is situated in the great dome, from which comes ample light through windows and vault lights set in the dome itself. These windows, hidden by parapets, are invisible from the outside.

No thought or justifiable expense has been spared in the planning or the equipping of the laboratories. In the Hydraulic Laboratory is a 1,500 gallon pressure pump. Heads up to 500 feet can be established by the pump in closed steel cylinders, which supply impulse wheels and provide for the study of flow through orifices — an important feature in any hydraulic work. There is also a canal for testing water wheels. Those requiring up to 50 cubic feet of water per second can be tested under heads up to 38 feet. A 30-inch Venturi meter and adequate storage and pressure tank equipment permit a wide range of tests.

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THE EDUCATIONAL BUILDINGS PRACTICALLY COMPLETED

and current periodicals on these subjects. Other special libraries are devoted to chemistry, physics, electrical engineering, geology, metallurgy, naval architecture and marine engineering.

The Margaret S. Cheney reading room, which was established about forty years ago, is located in the main educational building. It is maintained from the income of a fund created by Mrs. Edna Dow Cheney. The Emma Rogers room in the main building was named in honor of Mrs. William Barton Rogers, the wife of Technology's founder and first president. The walls are handsomely panelled in oak, making an attractive reception room for the women students.

Eastward of the educational group facing the river is the Walker Memorial, erected by the alumni in memory of General Francis A. Walker, former president of the Institute. It is the club house and headquarters for the students, a meeting place for the various activities of club life, and a place of recreation and amusement. The Memorial is a three-story reinforced concrete building, beam and girder type for the first two floors and steel trusses on the third floor over the gymnasium and supporting the roof. The exterior walls are Roman brick with limestone trimmings. There is an imposing entrance from Charles River Road, consisting of a broad flight of limestone steps and a portico of Doric limestone columns. At the ground level is a low granite base course. The floor finishes are granolithic and maple.

The second floor in the Walker Memorial consists of reading, writing and social rooms, with special rooms for the faculty and alumni, and a handsome library. On this floor also is a room for the meetings of the directors of the Institute.

The dining hall on the main floor of the Walker Memorial is used also as an auditorium. Extra seating space is provided in the balcony on the second floor. The remainder of the main floor consists of the lobby and several lounging rooms.

One of the popular features of the Walker Memorial is the gymnasium on the third floor, directly above the auditorium. Conveniently located on the same floor are shower baths, toilets and utility rooms. Here also are located most of the offices of the student activities. Billiard rooms and bowling alleys are located in the basement.

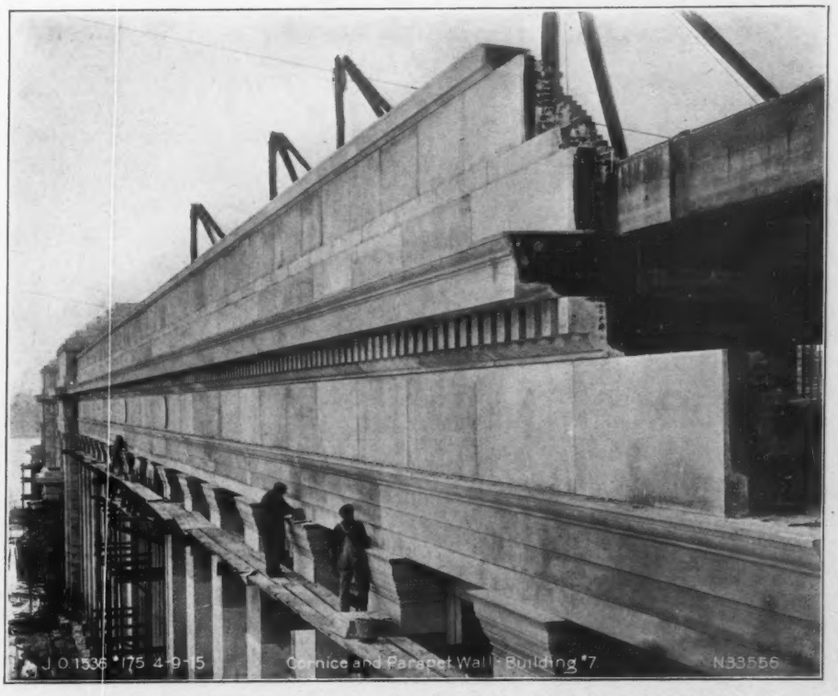
Looking further eastward along the Cambridge waterfront, we have the dormitories and the president's house. The dormitory buildings are constructed in two wings, four stories high, radiating from the central tower of six stories, and terminating at each end in a three-story bay. The president's house occupies the southwestern corner of the plot. The three-story bays at the two extremities of the dormitory buildings are headed with flat pilasters, decorative niches and an open balustrade above. Projecting bays mark the entrance to the different student houses and break the long wall surfaces of the two wings.

The first floors of the dormitory sections are devoted to single bed rooms and the remaining floors to suites for two or three men, usually consisting of a study, dressing room, and bed room. Toilet facilities are provided on each floor, and most of the single bedrooms are equipped with lavatories. Every section in the dormitory buildings has its own entrance and staircase, making each a complete unit. The end sections are occupied by fraternities, which have their own kitchens and dining rooms. The dormitories have 130 rooms, accommodating approximately 230 men.

The President's house faces the Charles River in the open court formed by the dormitory group. It is surrounded by a wall enclosing at the back a formal garden with brick walls, tea house, fountain and shrubbery. From the dormitory windows overlooking the quiet beauty of this formal garden one views the smoking chimneys and busy thoroughfares of an industrial city.

The President's house is constructed

(*Continued on page 120*)



CORNICE AND PARAPET WALL OF BUILDING THREE UNDER CONSTRUCTION

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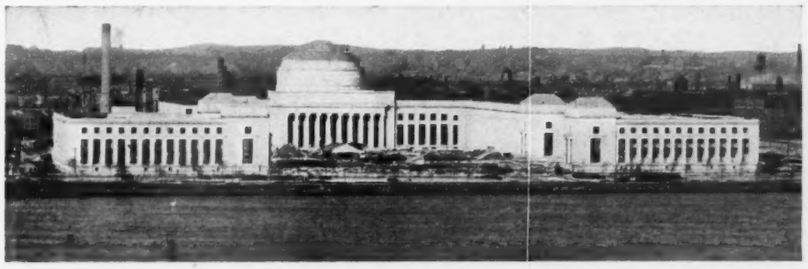

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The Margaret S. Cheney reading room, which was established about forty years ago, is located in the main educational building. It is maintained from the income of a fund created by Mrs. Edna Dow Cheney. The Emma Rogers room in the main building was named in honor of Mrs. William Barton Rogers, the wife of Technology's founder and first president. The walls are handsomely panelled in oak, making an attractive reception room for the women students.

Eastward of the educational group facing the river is the Walker Memorial, erected by the alumni in memory of General Francis A. Walker, former president of the Institute. It is the club house and headquarters for the students, a meeting place for the various activities of club life, and a place of recreation and amusement. The Memorial is a three-story reinforced concrete building, beam and girder type for the first two floors and steel trusses on the third floor over the gymnasium and supporting the roof. The exterior walls are Roman brick with limestone trimmings. There is an imposing entrance from Charles River Road, consisting of a broad flight of limestone steps and a portico of Doric limestone columns. At the ground level is a low granite base course. The floor finishes are granolithic and maple.

The second floor in the Walker Memorial consists of reading, writing and social rooms, with special rooms for the faculty and alumni, and a handsome library. On this floor also is a room for the meetings of the directors of the Institute.

The dining hall on the main floor of the Walker Memorial is used also as an auditorium. Extra seating space is provided in the balcony on the second floor. The remainder of the main floor consists of the lobby and several lounging rooms.

One of the popular features of the Walker Memorial is the gymnasium on the third floor, directly above the auditorium. Conveniently located on the same floor are shower baths, toilets and utility rooms. Here also are located most of the offices of the student activities. Billiard rooms and bowling alleys are located in the basement.

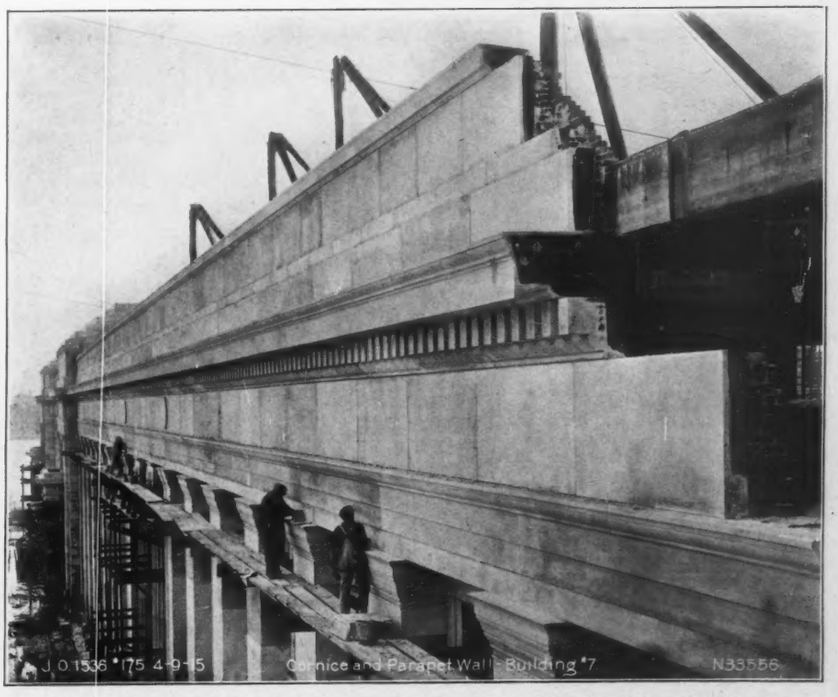
Looking further eastward along the Cambridge waterfront, we have the dormitories and the president's house. The dormitory buildings are constructed in two wings, four stories high, radiating from the central tower of six stories, and terminating at each end in a three-story bay. The president's house occupies the southwestern corner of the plot. The three-story bays at the two extremities of the dormitory buildings are headed with flat pilasters, decorative niches and an open balustrade above. Projecting bays mark the entrance to the different student houses and break the long wall surfaces of the two wings.

The first floors of the dormitory sections are devoted to single bed rooms and the remaining floors to suites for two or three men, usually consisting of a study, dressing room, and bed room. Toilet facilities are provided on each floor, and most of the single bedrooms are equipped with lavatories. Every section in the dormitory buildings has its own entrance and staircase, making each a complete unit. The end sections are occupied by fraternities, which have their own kitchens and dining rooms. The dormitories have 130 rooms, accommodating approximately 230 men.

The President's house faces the Charles River in the open court formed by the dormitory group. It is surrounded by a wall enclosing at the back a formal garden with brick walls, tea house, fountain and shrubbery. From the dormitory windows overlooking the quiet beauty of this formal garden one views the smoking chimneys and busy thoroughfares of an industrial city.

The President's house is constructed

(*Continued on page 120*)



CORNICE AND PARAPET WALL OF BUILDING THREE UNDER CONSTRUCTION

THE NAVY'S RELATION TO COMMERCE AND INDUSTRY

By LIEUTENANT COMMANDER R. R. M. EMMETT
United States Navy

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The people of the United States are today confronted with their destiny and that destiny lies in great measure on the sea.

The young man of ambition has a different picture presented to him as he goes out into the world, than had his father or his grandfather before him.

For three-quarters of a century the most attractive careers for each rising generation lay at home. Ours was a country of boundless natural resources, of noble opportunities. There was no limit, other than a man's ability, to what could be accomplished at home.

Our relations, both political and economic, with the world abroad were extremely simple. There was no economic demand that our people should go down to the sea in ships and hence we have had no merchant marine worthy of the name. Having no merchant marine to support and secure, our navy waned to a nominal force, largely composed of old and obsolete ships. It was natural that this should be so. There were no political or economic reasons for maintaining a greater force.

As the country discovered and developed its great natural resources and grew rich and prosperous, men of vision here and there, all over the country, foresaw the need of securing our prosperity. A start was made toward the creation of our modern Navy. Men preached the need of developing merchant shipping to transport our products throughout the world.

Progress was necessarily slow. Opportunity to live comfortably ashore abounded, and men were slow to earn their bread at sea.

The Spanish-American War, with its aftermath of new interests and responsibilities, pushed on our naval development. The manifest need of securing the Monroe Doctrine from the selfish assaults of foreign powers continued the expansion of our Navy.

The application of the Monroe Doctrine has successfully safeguarded, for one hundred years, the affairs of this hemisphere from complications that might have threatened the peace of the world. It has permitted the people of all nations in the two Americas to work out their national problems without interference or exploitation from abroad.

The outbreak of the World War plunged us, whether we would or not, into the turmoil of world affairs. We have emerged from that conflict, for the present at least, the richest and most influential nation in the world. Whether we are to maintain our present relatively happy position in the family of nations rests with ourselves. There can be no doubt but that the genius and industry of our people, the soundness of our political and economic institutions, will enable us to bear prosperity as well as we have supported and borne the strife for prosperity. We must, however, take stock for the future.

The accompanying article, and the following message from Secretary of the Navy, Denby perhaps contain some ideas that may be new to Technology men. However, believing that there are in them some thoughts that justify the consideration of men looking to the future of the United States we are very glad to offer our columns, together with other members of the Engineering College Magazines Associated to aid Secretary Denby in putting his message before the engineering students of the country. —Editor.

STUDY SEA POWER

Young men launched into the world today face a new perspective. The United States stands as a world power. Its commerce carried in American ships, manned by American citizens, secured by an American Navy, second to none, will traverse the seven seas.

I know nothing more important to commend to the minds of our young men than, first, to study the inevitable influence sea power will exert on their country's future economic development; and then, to translate convictions gained into deeds which will react to the security, prosperity and happiness of our great Republic and its people.

(*Signed*) EDWIN DENBY

We have a large and increasing population, a great portion of which has assumed a highly industrial character. Our natural resources have been pretty well discovered, are in course of development, and can be accurately estimated. If the standard of living of our people is to be preserved; if we are to be fed as American citizens have been fed in the past, we must make better and more scientific use of both our industrial and agricultural resources. Our home markets now, with the passage of the years, approach the saturation point. It is becoming increasingly imperative to produce more goods than we can absorb at home. The building up and development of foreign trade and commerce is becoming an essential to our future economic prosperity.

Mexico and the countries of Central and South America are, figuratively speaking, at our doors. Great opportunities await men of ambition, brains and energy in China, Central Asia, the Near East and in Africa.

If our young men go out into the world to compete for the business of the world, they must be served by American ships. If they are served by the ships of other nations, our competitors, they must pay a toll to those foreign ships. If for a time, in spite of that, they are successful, we cannot complain if other nations who control the sea transportation of the world meet our success by taking advantage of such control to prevent our goods from moving about the world with the necessary precision as regards time, amount and place. We must develop our own merchant marine. We can and will develop our own merchant marine.

The history of the world can be analyzed and resolved into a few fundamental principles. History invariably has repeated itself and will again. No nation has ever built up a seaborne trade and commerce unless the ships that served that trade were supported and secured by an adequate naval force.

Admiral Mahan in his two great books entitled, "The Influence of Sea Power on History," and "The Influence of Sea Power on the French Revolution and Empire," traces with matchless clarity the political and commercial development of the Europe we know today. Their contents are being applied by the statesmen of Europe. The history of the Japanese Empire in the past twenty-five years has been substantially guided and influenced by their existence. The principles adduced and analyzed are particularly applicable to our own country, a country that seeks wealth, prosperity and consequent happiness, not by the sword, but rather by honest, industrious labor.

We in the United States have been accustomed to give little thought to our need for a merchant marine, or, if we have considered it at all, only as something seen dimly, in the distance. We have been accustomed

(*Continued on page 113*)

SAMUEL MORSE FELTON

In writing a sketch like this of a man who has been as active as Mr. Felton, it is particularly hard to keep it from simply becoming a "Who's Who" chronicle of the positions he has held. He has been so active that a list of his positions would alone fill the required space.

Samuel Morse Felton was born February 3, 1853 in Philadelphia. He early became acquainted with transportation problems as his father, also Samuel Morse Felton, was among the pioneers in railroading. The elder Felton was Superintendent of the Fitchburg Railroad in 1843. In 1861, as President of the Wilmington and Baltimore Railroad he had the honor of directing the secret passage of Abraham Lincoln from Harrisburg to Washington.

Young Felton took an engineering course at the Pennsylvania Military Academy for two years. Then he spent one year in the field with a locating party on the Lancaster Railroad in New England. Realizing the value of more technical training he entered the Massachusetts Institute of Technology and, after two years, in 1873, was graduated with the degree of Civil Engineer. Immediately following his graduation, because of his earlier experience in the field, he was able to accept a position as Chief Engineer on a small road being constructed by the Reading Railroad on the Delaware River.

SAMUEL MORSE FELTON

Mr. Felton has had experience in railroading in the most diverse parts of America. In 1884, he became connected with the Erie Railroad, first as General Manager in charge of their Western Lines, and finally first Vice-President in charge of traffic and operation of the whole system. In the fall of 1890 he was made President of what was then known as the East Tennessee, Virginia, and Georgia System, which included a part of the Queen and Crescent System. He remained in the South for ten years, most of the time as Receiver of the Cincinnati, New Orleans, and Texas Pacific Railroad, and President of the Alabama Great Southern. In 1899 he was made President of the Chicago and Alton Railroad.

Perhaps Mr. Felton's most spectacular service has been that which he has rendered the United States during the Spanish American War, and more recently during the Great War. During the Spanish American War while in charge of the Cincinnati, New Orleans, and Texas Pacific Railroad his company moved a larger number of troops than any other single line. At the outbreak of the war they handled the first troop movement south to Chattanooga, which consisted of thirty-one trains which left Cincinnati ten minutes apart and reached Chattanooga, every one on time, without any delay or accident. This, at the time, over a single track road, was considered quite an achievement.

During the Louisiana Purchase Exposition at St. Louis, the Chicago and Alton Road had the distinction of being the only line into St. Louis without an accident to a passenger, and was reported to have handled in and out of St. Louis more passengers than any other road.

In June, 1916, Mr. Felton, then President of the Chicago Great Western, was asked to organize troops to operate railroads in Mexico, in case our army advanced south of the Rio Grande. His title at that time was Consulting Engineer and Adviser to the Chief of Engineers.

During the Great War the entire railway transportation of the American Expeditionary Forces was under the direction of Mr. Felton. When war was declared with Germany he was requested to organize nine railway regiments for service abroad. Five construction regiments were soon assembled and two more were recruited later. Shop and operation regiments were also organized. All these were composed of men who had had a large amount of experience in railroading. The following quotation from *Technology's War Record* gives the best view of his multiplicity of duties at that time.

"When this work had been completed, on July 15 Mr. Felton was appointed Director General of Military Railways, United States Army. His duties were enlarged to include not only the organization of railway troops, but also the procurement of equipment, supplies, machinery, and floating equipment connected with the transportation service abroad. At the time of his appointment he moved to Washington and made his residence there until February 15, 1919, when he returned to Chicago, having been relieved from the service at his own request on December 31, 1918.

"A general idea of the amount of work that was handled by Mr. Felton may be gained when it is realized that 83,181 officers and men were organized in the Transportation Corps and actually in service, and an additional 49,768 had been authorized at the time of the armistice. Up to that date there had been purchased 3,750 standard-gauge locomotives, 1,547 light railway locomotives, 91,519 standard-gauge cars and 8,530 cars for the light railways. Of this number 1,305 standard-gauge locomotives, 406 light railway locomotives, 19,163 standard-gauge cars and 4,831 narrow-gauge cars were either in France or on the ocean. Two general repair shops were equipped for standard-gauge locomotives; two for narrow-gauge. One extensive car erecting shop was completed; thirty-six engine houses were designed and partly built and 749,345 tons of eighty-pound rail purchased, sufficient to lay 5,961 miles of single track. Of this amount 298,923 tons had been sent overseas at the time of the armistice. In addition to this, 979,526 tons of narrow-gauge and light railway rails and tracks were purchased. The total tonnage of all commodities amounted to 3,380,377 tons, of which at the time of the armistice, 1,043,766 tons was in France or on its way. In addition to the organization of the

(*Continued on page 122*)

A SURVEY OF COSTA RICA

By EDWIN SHARP BURDELL, '20

Representative of the Bureau of Economic Research, Citizens National Bank, Los Angeles, Calif.

The author wishes to acknowledge the assistance of Mr. John M. Keith, Banker, San José, Costa Rica, in the preparation of this survey.

The greater part of Spanish America is situated between twenty-three degrees north of the Equator and twenty-three degrees south, which contains the tropical and sub-tropical regions of the world. That material progress is arrested by the influence of latitude is manifest by the fact that no large and important cities appear in the tropical and sub-tropical regions, except where topographical and meteorological conditions greatly modify the climate. In the proximity of the Tropic of Cancer are the City of Mexico, New Orleans, Havana, in the Western Hemisphere; Calcutta, Bombay and Canton in the Eastern Hemisphere, with a large hinterland to the north. In the Tropic of Capricorn are Rio de Janeiro, and farther south Buenos Aires, Santiago and Valparaiso de Chile, Melbourne and Capetown. Where material progress exists in the tropics, it is largely located in regions protected by their topography from water-laden winds blowing from the ocean and on high, sheltered plateaus. Hence, the development of the western coast of Central and South America, while the eastern coast, with its exposure to the winds from the Atlantic and the Caribbean, is still in primeval forest.

The Spanish Conquest was one of the greatest achievements of civilization in history in having been able to assimilate the native races and establish western civilization in the tropical regions of America, that have developed into the Republican form of government with democratic ideals. The revolting Spanish Colonies were the first to liberate their slaves; and while they gave the people political emancipation, they were never able to achieve economic emancipation on account of the low price levels of their products, which has prevented the realization of a standard of life compatible with the political aims of their Governments and the social aspirations of their people through public education.

The casual observer is too inclined to judge tropical America by the lack of material progress, losing sight of the fact that the Spanish American civilization rests on human rather than on material values.

Its social organism is the great stabilizing force behind the constructive efforts of four centuries that has withstood the vicissitudes of the climate and the destructive forces of nature. The colonies were far removed from the mother country, with uncertain means of communication, largely dependent upon their own resources, under political régimes, good, bad and indifferent. Few people have democratic principles so firmly rooted in their social organization and strive more earnestly to express these principles in their political institutions, although their governments at times appear to be a negation of these principles, according to our standards.

In spite of almost unsurmountable ethnic difficulties in the way of their realization, regardless of repeated failures and disillusion, they cling tenaciously to the highest expression of democratic principle, with the same faith that its church upholds its ethical principles in spite of the weakness of human nature.

The price levels of tropical products have been determined in the mentality of the world by the cost of production during centuries of slavery, exploitation and oppression, that have been characteristic of the tropics from time immemorial. Apart from the effect of slave labor in establishing a basis of cost value, the tropical producer has to contend with the low productivity of the soil, due to latitude, climatic conditions and its impoverishment through erosion.

In addition to economic and geographical difficulties, the climatic conditions of the tropics are such as to defeat mental and physical effort. Both natives and aliens are slaves to the pestilential diseases and maladies engendered by the tropical climate. One who has never lived in the tropics cannot conceive of the eternal warfare between man and nature. It is a common error in the North to consider the tropics as the most fertile portion of the earth and attribute its lack of material development to the indolence of its inhabitants. Such is not the case. In the tropics the human race has its greatest struggle for existence. Human labor and wealth are not cumulative to the same degree as in the temperate zones. The destructive forces of nature continually impinge on the constructive effort of man.

The advancement of Spanish America is arrested by keen competition from the Eastern Hemisphere, that has a still lower standard of living than that of the West. The creation of an increased market for American products in Spanish America is, therefore, inseparably connected with the destiny of the East. In the world's policy with regard to the tropics and sub-tropics of the East, as well as the West, lie the hope and despair of the industrial system of the North. The enormous increase of the productive power of man inaugurated by the use of labor-saving machinery has created commercial and political

PICKING AND TRANSPORTING COFFEE

This is the principal occupation of the people of Costa Rica. Note the peculiar method of yoking the oxen.

rivalries that led to the late war, which, after its enormous sacrifices, has left unresolved the grave social problems that existed at its beginning.

The improvement in the social standards of the inhabitants of the tropics, which bear hundred of millions, would create an outlet for the increased industrial products of the world. The continuance of the tropics as a region of exploitation of cheap labor and a source of acquisition of cheap raw materials could only accentuate the destructive forces now apparent in the industrial capitalistic system.

Costa Rica has much in common with the other Spanish American republics in the economic questions of the present. Sixty years ago, through the influence of the first English commercial traders, who financed their importation of merchandise by the exportation of coffee, the main energies of the country were devoted to coffee cultivation. The liberal economic theories of Great Britain, three quarters of a century ago, appealed to their imagination, and they readily accepted the theory that the welfare of the country was best served by devoting their energies to the cultivation of its most profitable, exportable crop, and by importing the necessities of life that could be purchased cheaper abroad than produced at home.

The changing customs of the people with the tendency to over-importation have been marked by periodic crises, which have been relived from time to time by the creation of foreign debts, and the importation of foreign capital, until the payment of tribute abroad has become an unbearable burden. This is more or less true of all agricultural countries, and fact of this tendency is expressed today in terms of force in Ireland, India and Mexico.

In area and population Costa Rica is one of the smallest of the Spanish American republics. In its development it has not had to face many of the great ethnic problems that its sister republics have had to contend with, as they are a homogeneous people, a large part or its population descending from the old Spanish conquistadores. The stock that brought western civilization to America and accomplished one of the most amazing feats of colonization recorded in history. Innumerable savage tribes scattered over a vast continent, which had only a rudimentary and crude agriculture, no knowledge of iron or steel, no work or milch animals — all fundamental elements of progress in the economy of human labor. The conquistadores united these tribes under a common language, religion and jurisprudence, giving them the arts, agriculture and traditions of the mother country.

Costa Rica, after acquiring its independence one hundred years ago, in spite of its poverty, sought to bring itself into closer contact with the outside world and establish a firm foundation for its interior development. In 1871 it began the construction of an interoceanic railway, now completed. It had already established the telegraph, also an admirable system of land registration, so good that litigation over a title is a rare occurrence. It has built schoolhouses in almost every town and village in the republic. Costa Rica was among the first of the Spanish American countries to realize the importance of sanitation, and commenced the sanitation of its principal port in 1893. Large sums have also been expended in the sanitation of its towns and villages. This enthusiasm for the material expression of progress has been costly and accounts for the heavy burden of debt that the country carries.

Costa Rica, like many of its sister republics, has attempted to finance a democratic form of government by an undemocratic fiscal system. It derives its principal revenue by indirect taxation through the customs and the liquor monopoly, the incidence of which falls on the people least able to pay.

The outbreak of the European war marked the collapse of its fiscal system by the reduction of its custom house receipts.

FOYER OF THE NATIONAL OPERA HOUSE

Costa Rica also has some very beautiful buildings which form a marked contrast to the crude plantations. This foyer is an exact replica of the foyer of the Paris Opera House.

Commerce

Costa Rica has two major exports, bananas from the tropical jungle lowlands near the sea, and coffee from the sub-tropical highlands from two to five thousand feet elevation. The banana crop is handled exclusively by the United Fruit Company. They have imported negro labor from Jamaica and the management of the plantations is in hands of Americans, so that aside from the revenues derived from the export tax the banana crop is not of such vital importance to Costa Rica as a whole.

The coffee crop on the other hand, touches every man, woman, and child for in good seasons the entire family is employed in some capacity at the coffee "beneficio" or cleaning plant. The red coffee berries are picked from the bushes during the early weeks of December. The berries are washed and the skins removed by hand or by machine. Then they are spread out on concrete floors or patios to dry. This drying period may take from one to ten days. The coffee plantations, or "fincas," vary in size according to the industry and good fortune of the farmer. Poor crops and low prices not only affect the farmer and his family but the sales fail to establish sufficient credits in the United States and Europe to take care of the large importations of merchandise.

In the fiscal year ending December 31, 1920, the total imports were valued at $48,107,500 while the total exports amounted to $32,115,200 of which $14,911,100 was derived from the coffee crop. Costa Rica is far too dependent on other countries for its means of subsistence. While it is too small to be entirely self-contained, yet if native capital and labor could

(*Continued on page 124*)

A PROPOSED SUPER-POWER CENTRAL STATION

By JOHN A. STEVENS
Consulting Engineer, Lowell, Mass.

Perhaps the most remarkable change that has taken place in the life of the people and in the industries of the world during the last thirty or forty years has been the rapid increase in the consumption of mechanical power. A man of two-score years ago consumed very little mechanical power. His food and supplies to a large extent came from nearby neighborhoods, brought by horsedrawn vehicles. He did comparatively little traveling, his home was lighted by kerosene lamps, and in most towns his water was pumped by hand from wells or drawn from springs. Many hand-made articles were in daily use and those which were produced in factories involved hand operations which have since been superseded by machine operations requiring the use of power.

The man of today, however, at every step is directly or indirectly a large consumer of power, from the moment he gets up and turns on the water for his bath to the time when on retiring he turns off the light and thus relieves the load on the lighting plant of his town. Not only has there been a great increase in the multiplicity and variety of manufactured articles, but there has been a corresponding growth in transportation and illumination. Raw materials, food supplies and produce are brought from all parts of the world, and manufactured products are as widely distributed. The great systems of electric transportation and electric illumination have come in, taking power from immense central stations.

It is obvious that with this enormous increase in power requirements some means must be provided for generating the power on a scale commensurate with the demand and adequate to the requirements of the future. This means larger stations, and the tendency toward bigger units is strengthened by the growing cost of fuel and labor, as it is a well-established fact that the larger units are more economical in both regards than the smaller ones.

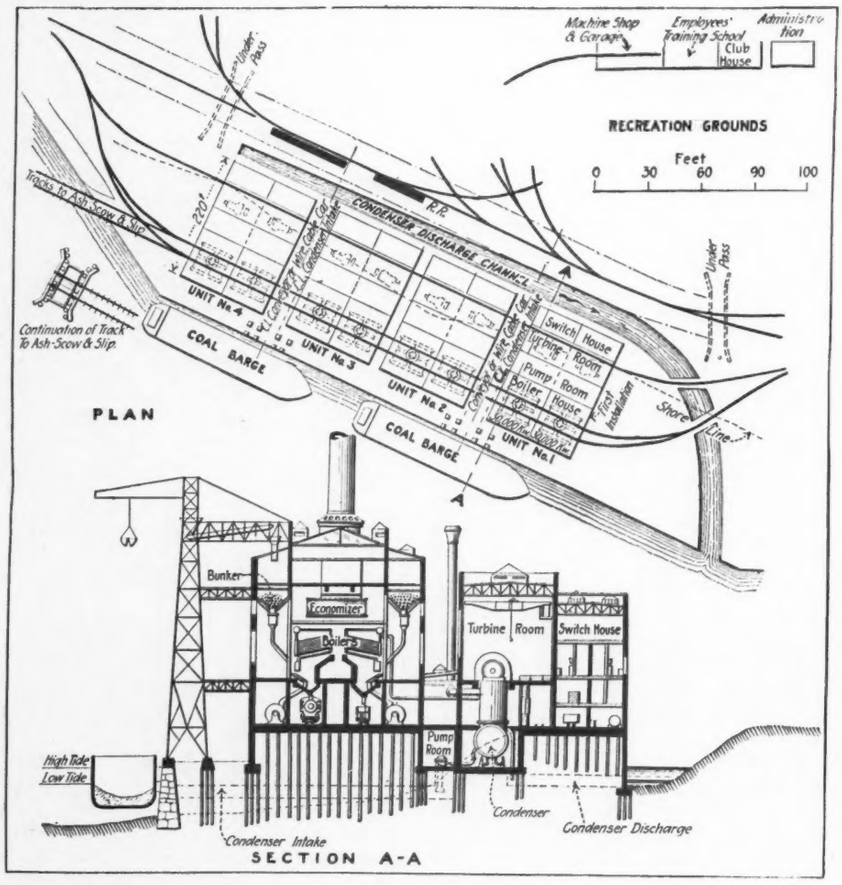
Nevertheless, the concentration of very large volumes of power generation in one unit involves certain not inconsiderable difficulties and dangers. Items that would be comparatively small in the central stations of moderate size become very big indeed in the giant installations. Furthermore, like the proverbial carrying of all the eggs in one basket, it involves great dangers in the way that a breakdown of a single big super-power central station would affect the life of the community to a far greater extent than a similar breakdown of only one of several scattered and possibly interconnected units.

It is to fulfill these conditions that the power station described in this article has been designed. It should be remembered, however, that this design is not due to any one man but is rather the work of a great many specialists. Neither is it believed that the design is final; we feel confident that there are still many improvements to be made.

The basic features of the plant are the use of a definite size of unit, namely 30,000 kw.; the separation of all boiler houses from their turbine rooms by "explosion gaps"; the separation of the turbines from each other by explosion walls; and the use of a particular type of turbine as the driving unit.

Thirty thousand kilowatts has been selected as the standard size of the unit as being the size within the zone of maximum economy in steam turbine engineering practice and also as being about the limit of the size that can be supplied with four sections of boilers served with one central stack. This size of unit, of which about eight would be used in the station, determines the general arrangement.

The central stack is to be three hundred to three hundred and fifty feet high in order to discharge the gases and dust at high altitudes. As such a station would be a vital spot in a national emergency a wireless aerial is attached to the stack and search-lights are mounted on the roof for protection. Referring to the figure it will be seen that the boiler house is practically an independent building, being separated from the turbine room by an "explosion gap", so called. This is provided for safety. Minor accidents such as tube failures and short circuits in the generator must be expected



PLAN AND ELEVATION OF A 240,000 KILOWATT SUPER STATION
Note explosion gaps between each 60,000 kw. unit.

and it is to localize the damage to the place where the failure occurred that this space is provided.

The same considerations of safety have lead to the adoption of a wall from twenty-five to thirty feet high to separate the various parts of the turbine room. If some steam fittings fail there is then some possibility of the operators reaching a place of safety. For similar reasons each unit of 60,000 kw. is separated from the others by a space of forty to sixty feet in the clear.

Among some of the unusual features provided are periscopes for observing the furnaces and reading the water gauge levels. Telephones are provided at all important points, for example, at or near the boiler-drum manholes, near the fans, etc., so that any accident or defect can be reported instantly. Above the umbrella on the stack and at the base of the umbrella, pipes are provided to wash off the dust that may collect on the plate glass roof, while underneath this roof a shade is installed on rollers so that on a hot summer day the operating room may be shaded and comfortable.

The turbines forming the main generating units of this station would be standard 30,000 kw. machines carefully designed to give maximum economy.

In cases where the super-power station is located close to large sources of demand for relatively low-pressure steam required for heating or manufacturing processes still further over-all economy could be effected by making some of its turbine units of special design. In place of the standard unit, there could be used a double-cylinder extraction and low pressure turbine. This would not of necessity always need to be physically located at the central station but instead, when more economical for construction reasons, could be located at the manufacturing plant and electrically inter-tied with the central system, thus making possible the utilization, of excess low-pressure steam which is at times available in large quantities, and which now often goes to waste from such manufacturing plants.

Such a turbine consists of high-pressure and low-pressure units mounted on one shaft with, say, a 10,000 kw. generator. This machine operates automatically with steam extracted from zero gage to, say, eighty pounds pressure, or from 0 to 244,000 pounds extracted at a predetermined pressure. It will operate entirely condensing with only a slightly reduced economy from that of a standard machine, and it will operate also for any intermediate extraction of steam or generation of power. At the same time large amounts of steam may be admitted into the low-pressure casings in the way of returns from vulcanizing machinery, which should be put through regenerators or separators at one- to two-pound pressure for the precipitation of the acids. The control of this machine is from the sustained or

SUGGESTED POWER TRANSMISSION LINES FOR SUPER-POWER ZONE

maintained pressure in the steam line to the manufacturing systems. In other words, the machine is controlled from its byproduct rather than from its electrical end; but at the same time, if more service is demanded of the electrical end than the proportionate amount of steam passing through the manufacturing processes would admit, the automatic valve mechanism will open to the low-pressure or condensing turbine the necessary amount of steam to follow the electrical demands.

In order that such a station may be operated economically large quantities of fuel must be easily obtained. Accordingly the station is either shown with facilities for handling coal from barges or from railroad. In either case, room is provided in the basement so that the largest rolling stock may be brought directly into the building. This is done for two reasons: first, for the coal supply; second, to handle large parts which may need replacing from time to time. However, as enormous quantities of condensing water are necessary, the station must be located either on a large river, lake, or perhaps ocean port.

When otherwise practicable, it will be well so to choose locations for central stations that later full advantages may be taken of economies to be brought about by the recovery and utilization of distillates and other chemical products from coal. This is a matter at present little thought of but likely to be of increasing importance in the future.

These stations would form the basis of the super-power zone outlined approximately on the accompanying map. In this way the hard and soft coal fields, Niagara Falls, Cedar Rapids on the St. Lawrence, and the Maine hydro-electric developments would all be tied into one grand scheme. The project would consider the use of river banks and railroad rights-of-way for transmission lines.

The time will come when no company or individual will be allowed to operate any plant at a thermal efficiency of less than a predetermined percentage; neither will any company be allowed to operate any turbines or equivalent machinery condensing when they could be operated non-condensing and the exhaust steam used in heating and manufacturing, or when purchased power from a large super-station can be made available advantageously. In other words, as coal and oil — in fact, all known fuels — are non-renewable natural resources, the general public will be forced to use the utmost care in their consumption.

NAVY'S RELATION TO COMMERCE

(*Continued from page 108*)

to think of our Navy and our strong right arm, as our bulwark in time of war, but as something in time of peace that was necessary, we supposed, but still required a heavy expenditure of the public funds that might be spent elsewhere to more apparent and immediate advantage.

We must revise our ideas; we must renew our perspective. The economic need for seapower is upon us, and by seapower I mean a fleet of American owned, American manned ships, running from great commercial ports to the ends of the world and back, supported and secured by a Navy trained to the razor edge of efficiency and second in power to none other on earth.

Nothing is more important to the future interest of the United States than a thorough realization by the rising generation of the great influence seapower will inevitably exert on their prosperity and happiness.

Civil Service Examinations are announced as follows: Computer, Coast and Geodetic Survey, October 4–5, and December 6–7, salary $1,400 to $2,000; Junior Engineer, Junior Technologist, Junior Physicist, Bureau of Standards, November 22, salary $1,200 to $1,500. Applicants should apply for Form 1312, stating title of examination desired, to the Civil Service Commission, Washington, D. C.; or to the Secretary of the local United States Civil Service Board.

Rubber in Paper. Frederick Kaye, Fellow of the Royal Chemical Society, England, has invented a process for introducing rubber latex in the manufacture of paper. Increased strength, better folding qualities, improved texture, and greater ability to resist water are among the merits claimed for paper made by this process.

About Two Thousand New Nebulæ have recently been discovered by D. H. Menzel on ninety photographs taken with a twenty-four-inch Bruce telescope at the southern station of the Harvard College Observatory at Arequipa, Peru, according to recent reports. Miss Annie J. Cannon at the same station is said also to have discovered a nova in the constellation of Scorpio.

Roller Bearings for Trains. Sir Henry Thornton, Manager of the Great Eastern Railways states that there has been devised a successful roller bearing for use in the construction of railway cars. According to him the development has been made possible by the great improvements in steel manufacture made since the war. A particularly hard but not brittle steel is used, which can stand a strain of twenty-one tons. One man can easily move a twenty-seven ton coach equipped with these bearings.

Airplanes are being used to locate and photograph undiscovered lakes in the national forests of Alaska. It has long been known that there are many lakes on the headlands and islands traversed by the inside passage between Seattle and Skagway that do not appear on any map. During the New York-Nome flight made by Army aviators, lakes were frequently sighted which could not be found on the latest and most authentic maps of the territory. Tales of unknown water bodies are constantly being brought in by trappers and prospectors. Less than a year ago a lake four and one-half miles long and one-half mile wide was discovered at the head of Short Bay. This lake has over one thousand acres of surface area and is less than one and one-quarter miles from tidewater, yet because of the surrounding country's rough topography has remained unknown and unnamed.

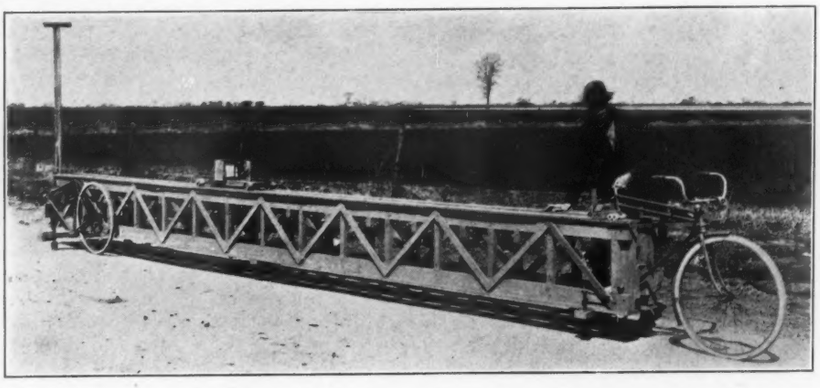
Recognizing that many other of these "lost lakes" may be sources of valuable water power, plans are being made to map this no-man's land of the north by means of aerial photographs. A few days' flight, it is said, will be sufficient to cover the area with a degree of accuracy that would require many years and great expense to accomplish by ordinary methods. The work, which has been approved by the Federal Power Commission, will be done by seaplane, flying from Ketchikan as a base.

Boron Steel. Experimental work performed by the United States Bureau of Mines indicates that the use of boron as an alloy confers marked hardness on steel. If the other physical properties of the boron steels are good enough to be applicable to commercial use, their remarkable plasticity at temperatures below the melting points of ordinary steels might make it possible to utilize this characteristic.

A Rubber-Eating Bug was found to have attacked the insulation of certain wires in St. Peter's Church in Singapore. Small bore holes were observed in the outer cotton covering and upon examination it was discovered that the rubber beneath had been completely removed. The matter is thought to be of considerable gravity for not only is the fire hazard attendant upon electrical installations greatly increased, but the rubber in warehouses is endangered by the existence of such a pecular insect. So far entomologists have been unsuccessful in locating the offender.

Ventilation Up-to-Date. All that is necessary when a member of the London County Council wishes fresh air or a change in room temperature is the pressing of a button. Reports say that the system is so well worked out that one member of the Council can change the atmosphere immediately surrounding him without affecting that about his neighbors. A remarkable feature of the ventilating apparatus is that the effect of a change in temperature or in the weather outside is promptly recorded in the sub-basement, where the ventilating machinery is placed, and the various machines are automatically caused to re-adjust themselves so as to maintain an even temperature and the proper humidity inside the building. A fall of rain or a brief spell of sunshine is immediately recorded and the instruments act accordingly.

Testing Smoothness of Roads. A traveler passing along a highway and seeing this apparatus might think it the latest development in touring machines, and sympathize with the fellow supplying the motive power. He would be entirely mistaken though, for it is an apparatus devised by engineers of the Bureau of Public Roads of the United States Department of Agri-



DEVICE FOR TESTING SMOOTHNESS OF ROADS

culture and used on a road test in co-operation with the Illinois State highway department. Its purpose is to measure roughness and uneveness in a road surface before and after traffic tests, which it does with an accuracy of a small fraction of an inch.

Utah Power Project. The Utah Power and Light Company has filed application with the Utah State engineer for permission to use 5,000 sec.-ft. and to develop by storage 300,000 acre-feet in the Green River in Daggett County. With this water it is proposed to develop 188,000 hp. of electric energy for use in Utah, Idaho, and Wyoming.

It is proposed to construct a dam a short distance down the stream, the water from this dam to be backed up well above the proposed diversion point, Flaming Gorge Canyon, just south of the Utah-Wyoming line where the Green River enters Utah. From the latter point a pressure tunnel 19,800 feet long would extend, according to the application, in a southeasterly direction, emptying into the Green River again in Red Canyon at a point some miles downstream. The pressure tunnel is to be 25 feet in diameter. It is to deliver water to five wheels, each 66 inches in diameter, measured from runner to runner, and of the reaction type. These wheels are each capable of producing 37,600 hp., according to the application, when operated under the proposed head which would vary from 415 to 350 feet.— *Journal of Electricity.*

Rubber Road Surfacing is being tried out in Colombo and in Galle, Ceylon, according to a report in the Rubber Age. It is said that a rubber dressing has been devised which gives a better surface, can be worked more easily, and can be applied with less labor than any other material thus far used. The preparation is made from a combination of scrap and pure rubber, and is laid in a similar manner to that used in laying tar and asphalt preparations.

Reducing Hematite with Methane. During recent experiments on the reduction of iron ores with fuel gases carried out at the Pacific Experiment Station of the Bureau of Mines, Berkeley, California, it was noticed that at temperatures up to 800°C. the methane in these gases was practically inert as compared with hydrogen or carbon monoxide. A number of experiments were then carried out with mixtures of methane and hydrogen over a wide range of temperatures to find out when the methane would begin to function actively as a reducing agent. While it reacted slowly at all temperatures tested, its reaction in the reduction of hematite to magnetite, the first stage in the reduction of iron, did not become sufficiently rapid to be of industrial importance until temperatures of over 900°C. were used. A rough approximation of the velocity constant of this reaction was made for all the temperatures at which tests were made in order to obtain some unit figures of value in designing industrial appratus for carrying out this reaction. The details of these experiments are contained in Serial 2382, which can be obtained from the Bureau of Mines, Washington, D. C.

Radio Lecture Course. According to a press announcement, the Universities of Wisconsin, Iowa, and Nebraska, Tufts College and New York University have announced lecture courses to be broadcasted from their respective radio stations. Dean Lough of New York University is also quoted as saying that "loud speakers" are to be used in the various class rooms, so that one professor may lecture simultaneously to several classes. At Tufts College, one feature of the plan is to have a course of popular nature for boys of about fifteen years of age. At certain specified periods the professor will answer by radio the questions which have been submitted by mail.— *News Letter* (Princeton Engineering Association).

Rubber from Milk-Weed is the latest scheme we have heard of. The Agricultural Commissioner of Michigan said recently: "The milk-weed is a plant of no present value, but it must be remembered that this lowly plant has a rubber content that varies from one-half to as high as six per cent. Suppose we were to select only the highest yielding milk-weeds, propagate them, and improve upon them. What then? Rubber from Michigan."

BOOK REVIEWS

Tackling Tech, by Lawrence W. Conant, '21. Camden, N. Y.: The Roland Press Co. 1922. $2.00.

L. W. Conant, '21 as one of Technology's men very prominent in undergraduate activites and life in 1921, has an ample fund of experience and knowledge from which to draw the subject matter of his book. The book might more accurately be termed "Scientific Management Applied to the Getting of a Technical Education." It is written with the characteristic completeness of an engineer and at the same time in a very interesting manner. The chapter on "Activities" and those concerning financing an education and systematizing of work stand out as particularly vital to the undergraduate.

General Relativity and Gravitation, by Ludwik Silberstein. New York: D. Van Nostrand Co. 1922. 5½×7½, 141 pp. $2.00.

This book is based on a course of lectures delivered by the author at the Conference on Recent Advances in Physics held at the University of Toronto in January, 1921. Only the general theory is given, a knowledge of the older Restricted Relativity being assumed. The mathematical theory including the Tensor Calculus, is concisely but adequately presented. The attitude of the author impresses one as frank and fair without skepticism or intemperate enthusiasm. To most readers the paragraphs of greatest interest are those free of mathematical symbols in which he indicates the point of view as it appears to him. While there may be little, if anything, in this book that is not contained in the writings of Eddington and others, this independent presentation of the case makes it of great value to the reader who is often trying to grasp what appears to be a proof but is really an assumption.

H. B. PHILLIPS.

Architects Specification Handbook. Detroit: The Truscon Laboratories. 1922. 8½×11, 52 sheets, loose-leaf. Gratis.

This is a collection of specification sheets covering waterproofing, dampproofing, oilproofing, technical finishes, floor hardeners (both metallic and chemical), protective steel coatings, and architectural varnishes.

Elementary Determinants for Electrical Engineers, by H. P. Few. New York: D. Van Nostrand Co. 1922. 7×5, 98 pp. $1.50.

Course VI men who have struggled manfully with the execrable algebraic meanderings found in the solution of the simultaneous equations derived from Kirchhoff's Rules, should rise *en masse* to thank Mr. Few for this exposition of determinants as applied to Electrical Engineering. The book consists of six chapters devoted respectively to an account of simultaneous equations in relation to Kirchhoff's Laws, the method of Sarrus for the solution of systems of three linear equations and Maxwell's rule for calculating currents in networks, the methods of evaluating determinants of any order, methods of solving problems arising in the use of the Wheatstone Bridge and similar systems of electrical measurement, the use of determinants in the problems of electrical communication, and Fleming's method of finding the resistances of networks. There is a goodly sprinkling of problems exemplifying the application of determinants to these problems.

(Continued on page 132)

EDITORIALS

ANOTHER YEAR

Another summer has passed away and these early October days find the Institute corridors again thronged with the eager searchers after truth and knowledge.

These early days, these first days of the new school year! What experiences they see, what meanings they have! The old friendships renewed, the new ones formed, the boisterous greetings, the recounting of the summer's activities, the many posters, the crowd in the lobby, the crowd in the Coop; the bewildered frosh, the hardened senior. The much advice, the discussion of profs, the glorious rebates; the many lines, new and old, conversational and actual. New days, great days!

And through it all the spirit of accomplishment, the feeling of work to be done, of ambitions, not always scholastic, to be realized. That seems the significant thing, the inspiring thing.

And THE TECH ENGINEERING NEWS most sincerely hopes that to each Tech student, this new school year will indeed bring success and happiness, the fulfillment of his desires and the realization of his ambitions.

THE COLLEGE STUDENT

It was refreshing to read, among the voluminous newspaper writings on the railroad strike, the statement of a railroad shop manager in the Middle West. He said that when the crisis caused by the walkout of the shop men came, college students were ready and willing to step into the breach and take their places at the lathe and planer. What was more significant, he said these men brought to their jobs a willingness to work, and work hard, a willingness to obey cheerfully, and most important of all, they brought a loyalty to the job that made their work something of interest, rather than drudgery.

The college man is so often conceived of as being a superficial sort of being, interested more in clothes, sports, theaters and such things than in the work to be done in the world, that a statement like that of this railroad manager is more than welcome. For while the type of college student that the common conception portrays undoubtedly exists, the really typical college man does realize that there is much to be done in the world, that the best way to do it is cheerfully and loyally, and that only by doing this work in the very best way, and so being of service to society, can he justify his demands upon society, and live his life to the full.

There are those who will say that in the case of these men in the railroad shops, the work was a vacation in a way; to them that work was only a temporary occupation at best and their enthusiasm was not overcast with the prospect of years of the same drudgery. All of which sounds reasonable and may perhaps contain a grain of truth; but the fact remains that they did have the spirit that makes for success in what, by the above argument, was for them a small thing. How unreasonable not to expect them to have it in the big things, in their life work!

On the whole, the college student seems to be learning those two great lessons, of hard work and loyalty to his work, very, very well. Whatever else he may take away from college, without those he cannot expect to go far.

THE TECHNOLOGY REVIEW

We shall soon welcome *The Technology Review* into the family of monthly publications at the Institute. Heretofore under the able guidance of Professor Rogers *The Review* has been published quarterly but the evergrowing Alumni Association has needed a more adequate news service than a magazine issued four times a year. To meet this need the staff has been reorganized and *The Review* will now be published monthly from November to May and in July.

The field of *The Review* has been somewhat broadened so that now it will touch on all phases of Technology life. In this way the Editors hope to bind the Alumni more closely to the Institute and also interest the undergraduate in the activities of our prominent Alumni.

THE TECHNOLOGY SERIES

THE TECH ENGINEERING NEWS plans to offer its readers a series of articles about the New Technology and its administration. They are to be written by men prominent in Institute history and are to have as the subjects such topics as the construction of the present buildings, the various laboratories, administrative work, existing departments and the plans for the future. The first one of this series appears in this issue and is a description of the new buildings.

It is sincerely hoped that these articles will be valuable, not only in being instructive, but also in that they may help to strengthen the definite tradition about the Institute and its home. Beyond a reputation for hard work and great excellence in a scholastic way, which is, of course, a highly desirable and commendable thing, there is a great lack of appreciation of our Technology traditions.

To be sure the Institute is too young, it has been expanding and developing too rapidly, for traditions, which are really the product of time and a long established order of things, to be built up. But the strongest college traditions are always based upon fact, though they are at the same time the distinctive and peculiar features that set apart life at one college from that at another. They provide these bright spots and high lights of college life that will be long remembered after many of the lessons will have been forgotten. Since facts are their ultimate basis, however, we believe that the presentation of the little known facts of Institute history and life, though they may at times seem prosaic, will bring not only a fuller understanding and appreciation of the Institute but will also establish a firm foundation on which a tradition worthy of the purposes and ideals of Technology may be based.

For the individual student there also appears to be great potential value in these articles. Were we asked what we thought to be of the greatest value to a freshman at the

Institute, ambitious to make the most of his time here, our reply would be, not only knowledge of text-books but also a "Knowledge of Technology organizations, activities, and administration." Too many Tech students go through their whole collegiate career without an adequate appreciation of the Institute and what it stands for.

Furthermore, they should be of utmost interest to alumni as well as undergraduates, for by far the greater number of Technology's graduates remember "Tech on Boylston Street" and have no idea of what the New Technology is like, and so probably do not appreciate what advances have been made since they were students. These articles, by placing some of this information before them, thus show great possibilities of being of very real value and benefit.

In this spirit, then, they are offered. May they fulfill their high promise and be a truly worthy contribution to Institute literature.

GLIDERS

This summer has seen some interesting and, it is to be hoped, instructive developments in gliders and gliding. An international gliding contest was held in France and there was particular interest in this meet for Technology men in that the only American entry was Edmund Allen, a Tech student, who was using the glider built here last spring by the Technology Aeronautical Engineering Society. The most sensational achievements were, however, accomplished in Germany by students of the Hanover Technical School. Their first performance of extraordinary quality was a flight of two hours and ten minutes. A few days later a flight of more than three hours was made. As this is written the newspapers publish accounts of a forty-nine second flight made by Glenn Curtis in which the glider took off from water. This is said to be the first successful glider flight of this nature.

Whether the superiority of the German flights over those in France, where they were measured in minutes and seconds, is due to design of the glider or to its manipulation is not entirely clear. It appears, however, that manipulation is the greater factor. It is said that in their record-breaking flights, the German students manœuvred very skilfully back and forth in rising currents of air to a considerable altitude and then volplaned down, landing sometimes as far as ten kilometers from their starting place.

It hardly seems reasonable to expect gliders, as such, to have more than instructional, and perhaps recreational, value. Their ability to carry weight is so small as to militate against their development for commercial purposes. On the other hand, their value in studying aeronautics would appear exceedingly great and it is to be expected that some very interesting lessons will be learned from this summer's experience.

Mr. Allen, during the early part of the contest in France, was among the very leaders. He unfortunately damaged his glider and, when repaired, the judges decided it was a new machine and his first flights were not considered in computing the final standings. Technology should be very proud of Mr. Allen and the men who assisted him in this work. for the prestige they gained for the school was very considerable.

It is understood that Mr. Allen saw some of the German flights and we look forward to his own story of his experiences and observations. It should be very interesting.

RECOMMENDED ARTICLES

Insuring California's Industrial and Agricultural Growth. Journal of Electricity, August 15, 1922. An exceedingly interesting description of the Pit River power development by Norman S. Gallison. It is well illustrated and complete.

Welding. Its Uses and Abuses. Journal of the American Society of Naval Engineers, August, 1922. Capt. E. P. Jessop, U. S. N., discusses welding in general and in particular with reference to where, when, how, and why.

Employment and Tactics of Aircraft in National Warfare. United States Naval Institute Proceedings, August, 1922. Although the author, Commander John P. Jackson, U. S. N., says in a foot-note that, since he is not an aviator, certain points in his article are taken second hand, he has succeeded in getting up a mighty interesting paper.

MEETINGS AND CONVENTIONS

A. C. S. Connecticut Valley Section: October 14, Amherst. Address by Dr. J. G. Lipman on a phase of the nitrogen problem.

Rochester Section: October 16, Rochester; Dr. Harvey of Princeton will speak.

A. A. E. Boston Chapter: October 13, 8 P.M., 715 Tremont Temple. Regular monthly meeting.

A. I. E. E. Boston Section: October 3, 8 P.M., Engineers' Club. Joint meeting with Boston Section, A. S. M. E. (See below.)

A. I. E. E. Meetings of Worcester Section: October 19 — Paper on the manufacture of wire, by C. F. Hood of the American Steel and Wire Co.; November 16 — Paper on electric meters, their principles of operation, installation, and use, by Messrs. C. D. Knight, G. M. Hardy, and others; December 21 — Paper on the principles of vacuum tubes, by H. H. Newell.

A. I. M. M. E. Boston Section: October 2, 6.30 P.M., Engineers' Club. Dinner and meeting. George B. Wood, President, Rockland and Rockport Lime Corporation will speak on "Limestone and Lime."

American Electric Railway Association. Convention and exhibit at the Municipal Pier, Chicago, October 2–6.

A. S. M. E. Boston Section: October 3, 8 P.M., Engineers' Club. Joint meeting with Boston Section, A. I. E. E., paper on "Gyroscopic Stabilization of Ships" by Alexander Schein of Sperry Gyroscope Co. October 17, "Management."

Chicago Section: October 18, Chicago Association of Commerce weekly luncheon at Hotel La Salle. Evening meeting at Auditorium Hotel. Both devoted to "Management." October 20, evening meeting at Auditorium Hotel.

New Haven Section: October 16. "Relation of Labor to National Progress."

Metropolitan Section: October 10. Fall Get-Together. October 17, Engineering Societies' Building. Joint management week meeting with Industrial Engineers and the Taylor Society. October 31, Newark, N. J. "Industrial Furnaces."

Philadelphia Section: October 24. Annual Smoker at Adelphia Hotel. Worcester Section: October 18, "Management."

Trip to Aberdeen Proving Grounds, Management Week, October 16–21.

Boston Society of Civil Engineers. Designers' Section: October 11, 6 P.M., 715 Tremont Temple. "A Discussion of the Foundations for the New Building for the First National Bank of Boston," informal talk by Howard K. Alden of Stone and Webster.

Sanitary Section: October 4, 7.45 P.M., 715 Tremont Temple. Prof. George C. Whipple on "Mosquito Control in Massachusetts."

First Pan-Pacific Commercial Conference. Honolulu, Hawaii, October 25 to November 8.

Fire Prevention Exposition. Twenty-second Regiment Armory, New York City, October 2–7.

LUBRICATION

(*Continued from page 105*)

this increase in the thickness of the film will result in a rapid decrease in the coefficient of friction. Eventually, however, a point will be reached where metallic contact ceases entirely and the bearing is carried on a perfect fluid film, with a very low coefficient of friction, around 0.002.

As the product $\frac{zn}{p}$ is still further increased, the separation of the surfaces continues, though at a much less rapid rate, since the maximum possible separation is half the diametrical

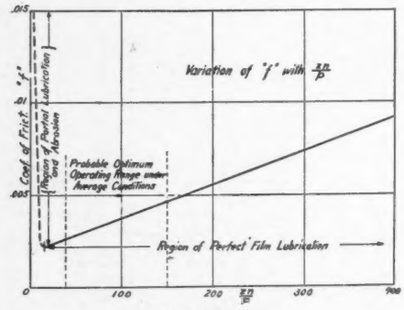


FIGURE 2

clearance, when the journal is perfectly centered. Furthermore, the increase in $\frac{zn}{p}$ beyond the critical point does not further decrease the friction, for the latter is now solely a matter of friction within the fluid film, and this increases in proportion to the speed and viscosity and is independent of the pressure (except at very high pressures). The coefficient of friction (friction divided by load) therefore increases with any increase in $\frac{zn}{p}$, and it has been shown by Professor Hersey* and the writers† that in this region f, the coefficient of friction of a given bearing lubricated by any fluid, is not an independent function of z, n and p, but only of their product in the form $\frac{zn}{p}$.‡

The behavior of any journal bearing may then be represented graphically by a curve such as that in Fig. 2, where f is plotted against $\frac{zn}{p}$.

The particular curve in this case is that for a well machined full bronze bearing without oil grooves and with a fairly large ratio of clearance to diameter $\frac{1}{250}$.

The position and shape of this curve varies somewhat for different bearings in a manner to be discussed later, but assuming it to be established for a given type of bearing, consider first its significance and practical application.

It is, of course, desirable to keep the coefficient of friction at a minimum, and in this bearing the minimum obtainable is 0.002 at $\frac{zn}{p}=12$. If the attempt is made to operate at this point, however, any slight or temporary increase in load or decrease in speed or viscosity will bring $\frac{zn}{p}$ below the critical point and the coefficient will rise precipitously. This part of the curve is essentially a highly unstable region because as soon as the coefficient begins to rise the bearing becomes hotter and the viscosity drops off, thus further decreasing $\frac{zn}{p}$ and making the bearing tend to seize.

It is therefore clearly necessary to operate further up in the region of fluid film lubrication, determining a proper operating value of $\frac{zn}{p}$, by multiplying the critical value of $\frac{zn}{p}$ by a suitable factor of safety. The magnitude of this factor of safety will depend upon the degree of constancy of the load and speed under operating conditions. For example, bearings which are frequently started and stopped must have a larger factor of safety than bearings which operate practically continuously. Suitable factors probably vary from 4 to 15, depending on the above mentioned and other conditions.*

If the conditions of load and speed are fixed for a given bearing, the determination of the proper viscosity of the lubricant (at the working temperature of the bearing) becomes merely a matter of substitution in the equation $\frac{zn}{p}=$ say 75, instead of a matter of guesswork based more or less on practical experience. If the desired viscosity is lower than that obtainable with the standard lubricants, the size of the bearing should be decreased, thus increasing p to a point where the corresponding value of z is readily obtainable.

It will be noted that in the region of fluid film lubrication, conditions are essentially stable, in contrast to the region of partial lubrication. If the lubricant is somewhat too viscous the bearing temperature will rise and the viscosity decrease, until a balance is reached, at an unnecessarily high coefficient, to be sure, but without really injuring the bearing or allowing the temperature to run away and produce seizing.

The use of Fig. 2 is also very helpful in diagnosing bearing troubles. If a bearing is overheating or in any way operating improperly, it is simple enough to determing whether $\frac{zn}{p}$ is too high or too low and correct the difficulty by a proper selection of the lubricant. If the trouble then still persists it must be due to mechanical difficulties — improper alignment, insufficient oil feed, etc. — which examination should readily disclose.

Possibly the most valuable use of the plot of f versus $\frac{zn}{p}$ is, however, in measuring the relative efficiency of different types of bearings, which has heretofore been largely a matter of guesswork, but is made strikingly clear by comparing the "f" curves for different bearings. The writers have plotted all the readily available data on this subject and have brought out several important points.* Bearings differ considerably, both in (*a*) the critical point at which the film ruptures, and (*b*) the slope and shape of the line in the region of fluid film lubrication. If we take as the best single measure of bearing efficiency

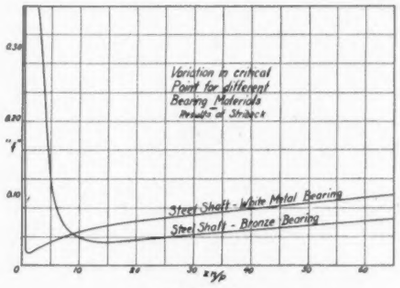


FIGURE 3

the value of f obtainable with a factor of safety of, say, 5, it appears that in general more can be accomplished by lowering the critical point than by lowering the position of the whole curve of fluid film lubrication. This point has received almost no attention in the past.

While the available data is as yet inadequate to give anything more than highly tentative conclusions, it appears that (*a*) decreased clearance tends to increase the slope of the line in fluid film lubrication (as would be

* "The Laws of Lubrication of Horizontal Journal Bearings" by M. D. Hersey. Trans. Am. Soc. Mech. Eng., Vol. 37, 1915.

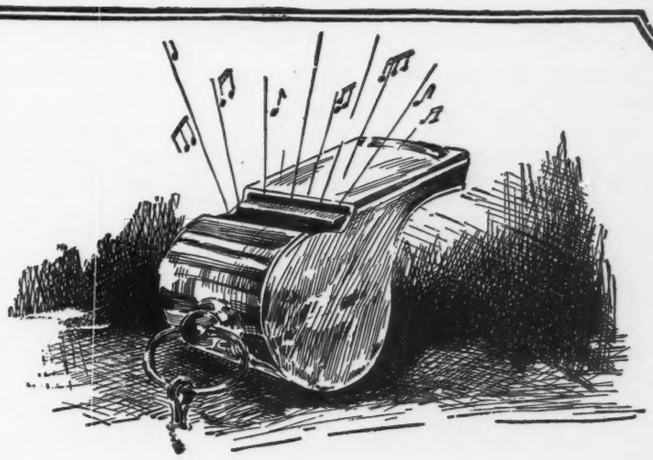
† Loc. cit.

‡ This is *not* true of the region of partial lubrication, where other properties of the lubricant than viscosity come into play.

* Where the direction of the load is changed during every revolution, as in a crankshaft bearing, the oil film does not get a chance to thin out, and operation can be carried on without difficulty at values of $\frac{zn}{p}$ around 10 or even lower.

*S. A. E. Jour. — loc. cit.

(*Continued on page 130*)



It will pay you to listen to this music

ALL over the country the whistle is blowing for the kick-off, the start of that great game—another college year.

Be on your toes when the whistle blows. A good start will carry you well on toward your goal.

Let the football candidate start by working away till his muscles ache from bucking the line.

Let the aspirant for manager put in careful study of his team's needs, always eager to help—arranging a trip or carrying a pail of water.

Let the publications man be alert for news and tireless in learning the details of editorial work.

Whatever activity you come out for, crowd a lot of energy into these early Fall days.

And if a good start helps win campus honors, it helps win class room honors, too. The sure way to be up in your work is to aim now for regularity at lectures, up-to-date note-books and particular attention to the early chapters of text-books, thus getting a grip on the basics.

This is best in the long run, and—selfishly—it is easiest in the long run. That is, if life after college is made easier by the things a bigger income can buy.

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Since 1869 makers and distributors of electrical equipment

Number 21 of a series

THE NEW TECHNOLOGY

(*Continued from page 107*)

of reinforced concrete, the exterior walls being limestone. The building consists of two stories and basement, with a third story tower. There are sixteen rooms and five baths above the basement; and ten rooms, two lavatories and one bath in the basement. All floors above the basement are oak. The living room, reception room, dining room and library have finely panelled walls, parquetry floors, ornamental ceilings and imposing fireplaces. The area occupied by the house and garden is two hundred feet square, and the wall surrounding it is of buff brick and limestone, eight feet high.

The Mechanic Arts building is two stories high with basement. It is 95 feet long and 85 feet wide, and is of reinforced concrete. The street façade has buff brick walls, the other walls being of red brick. The architectural trimming is stone. The floors have granolithic finish. The partitions are terra cotta.

The power house has a capacity of 15,000 kilowatts. It supplies electric current for lighting and power. The boiler house, in addition, provides steam for heating all the Institute buildings.

There has recently been added to the Institute group a new building approximately 60 feet wide by 175 feet long, four stories high, known as the Pratt School of Naval Architecture and Marine Engineering. The new building is an extension of the west wing of the main group and fronts on Massachusetts Avenue. It was built from a fund left for this purpose by Charles Herbert Pratt, in whose honor the school has been named.

The west elevation, which is strictly Greek Ionic, has been pleasantly rendered in limestone with large windows in every bay. The central bay of this facade, which is the main entrance to the building, has a pair of heavy bronze doors with Napoleon grey marble trim, surmounted by a Napoleon grey marble ship of the Trireme type. The rear, or easterly elevation, is built of light buff brick with limestone trimmings and forms the westerly side of the east secondary court. In the basement there is a large power measuring laboratory extending almost the entire length of the building. On the opposite side of the corridor there is a locker room, a heating and ventilating chamber, and a space for the vacuum pumps.

The building arrangement on the first floor comprises class rooms and departmental offices each side of the main entrance hall. Opposite the entrance hall is the museum where numerous models of ships are on exhibition. The second floor is used principally for class rooms, except the northerly end, which has a large model and cutting room equipped with up-to-date wood working machinery. The third floor comprises a large lecture hall, two stories high, with a seating capacity of four hundred and sixty-eight. A drafting room and offices complete the layout of this floor. The fourth floor is used for marine drafting and is lighted by two skylights running the full length of the room with windows on the court side only. This floor also contains a moving picture booth, which is used in connection with the third floor lecture hall. This booth is equipped with the latest model moving picture machine and a new stereopticon lantern.

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Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanics Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The coöperative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

The tuition fee, not including breakage in the laboratories, is $300 a year.

For catalogues and information, address

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FELTON

(*Continued from page 109*)

railway troops for France, 288 railway officers were sent to Russia from San Francisco, on December 30, 1918, to aid in operating the Trans-Siberian road.

"The total purchases made by the office amounted to $612,000,000. The material left over at the time of the armistice in this country was practically all disposed of at cost, and the material and equipment abroad has since been disposed of by international agreement.

"During the summer of 1918 Mr. Felton crossed the ocean and inspected all our transportation facilities in France, visited the ports where we handled our troops and supplies, and inspected the standard-gauge and light railways on the English, French, and American fronts, covering about twelve thousand miles in his trip.

"Upon his resignation he was awarded the Distinguished Service Medal — the first one granted a civilian. The French Government later conferred upon him the title of Commander of the Legion of Honor."

At present he is President and Director of the Chicago-Great Western Railroad, President and Director of the Leavenworth Terminal Railway and Bridge Company, President and Director of the Mason City and Fort Dodge Railroad, President and Director of the Western Railroad Association, Member of the Executive and Standing Committees of the Association of Railway Executives, Director of the Equitable Life Assurance Society of New York, besides holding many other responsible positions.

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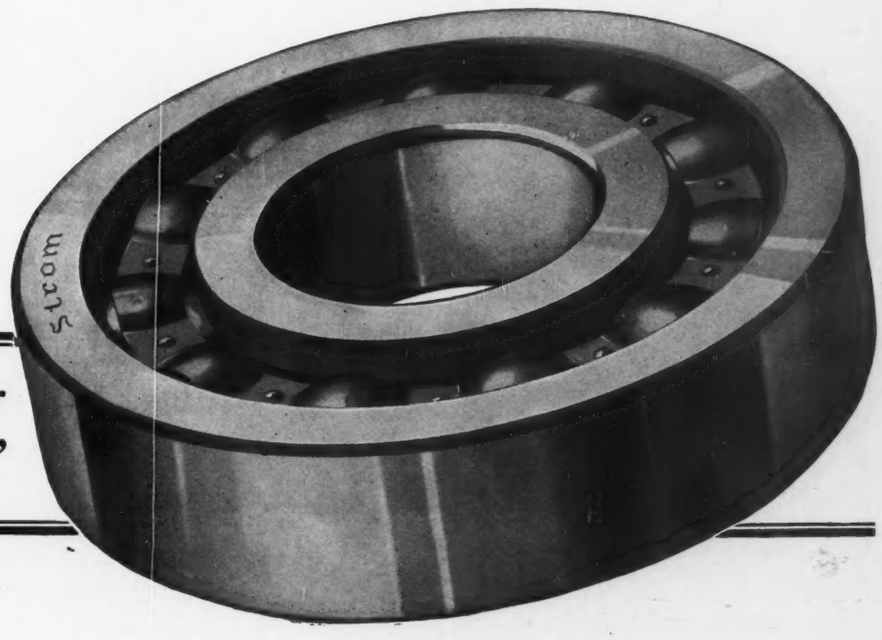

A SURVEY OF COSTA RICA

(*Continued from page 111*)

be directed toward more diversified farming and development of manufactories the government would not find it necessary to resort to foreign loans to make up the unfavorable trade balances.

Imports

During the war and shortly after all Central America bought heavily of the United States. The tendency now, however, is toward Europe and the imports from the United States dropped last year by 25 per cent. This is due to a variety of unfavorable factors, some of which could be corrected on the part of the American exporter.

In the first place dollar exchange is higher than pound, franc or lira exchange. That, time alone can correct. The terms of sale demanded by American exporters, however, are far too stringent and must be modified to meet European competition. When the American demands thirty to sixty days, the European allows three to six months. The Latin does not do business in a hurry any more than he does anything else in a hurry and it is fatuous to think we can compel him to adopt our psychology of business.

Faithfulness in complying with specifications concerning export goods is perhaps one of the most important factors in foreign trade and yet there are thousands of instances on every hand where the American exporter has decided that "something else is just as good" and takes it upon himself to ship goods which likely as not are utterly unsuited to the trade for which they were intended. This is

(*Continued on page 126*)

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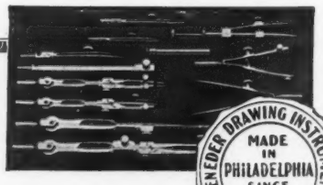

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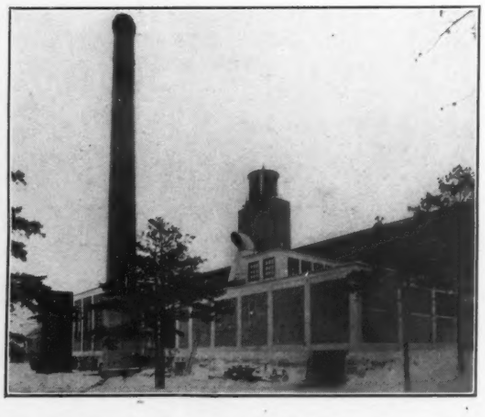

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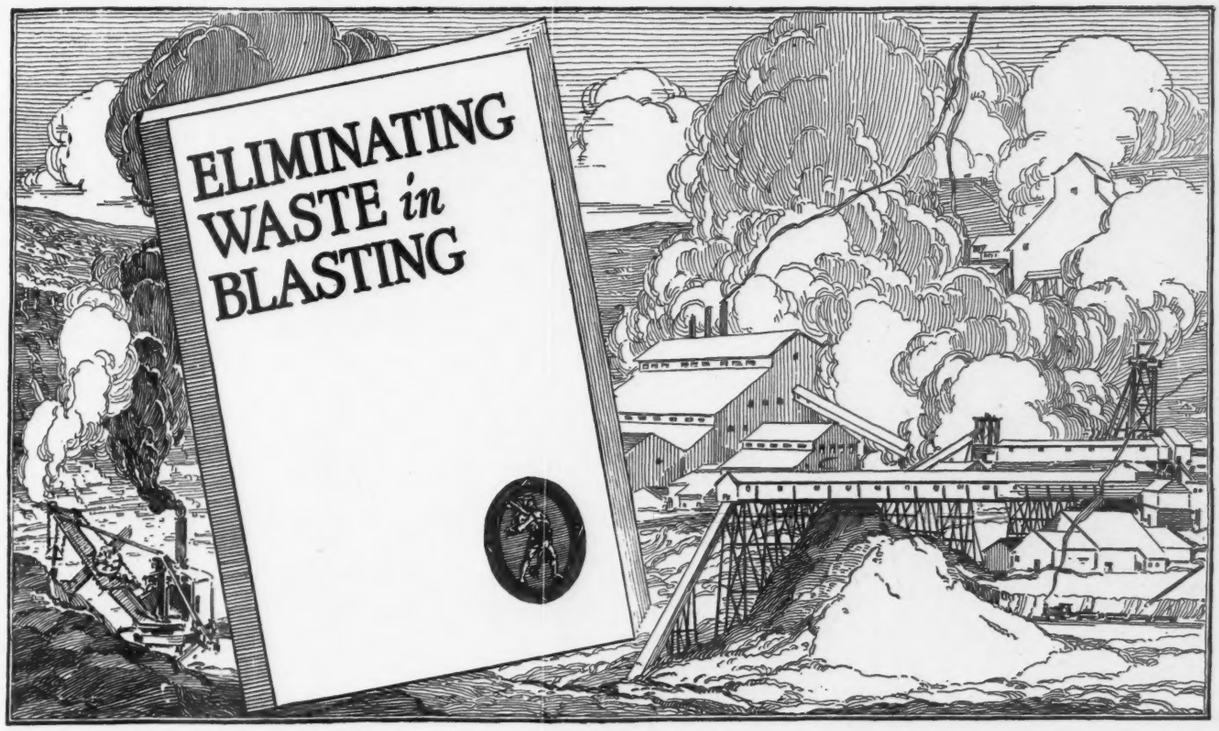

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A SURVEY OF COSTA RICA

(*Continued from page 124*)

simply another instance of the Anglo-Saxon trying to force the Latin to adopt his way of thinking. Another feature of foreign trade with Central America is satisfactory packing. This feature the American fails to grasp. All dry goods and perishables should be placed in water tight containers and in crates at least twice as strong as would be required in the United States. Just because there happens to be a dock and warehouse at the port does not signify that every shipment will be adequately protected. On the west coast of Central America and Mexico all freight is swung over the side of the vessel into a barge and the barge towed a mile or two to a small wharf and there it is hoisted onto a dock and the warehouse may or may not be near the dock. Add to these physical difficulties the torrential rains against which nothing is safe and also the native indolence and carelessness to which everything is subjected.

There is a great opportunity in Costa Rica for investments in manufactories. There are unlimited power possibilities. The present rate is one colon or about twenty cents per month per light fixtures regardless of power consumed. The same is true of motors, payment is made on rated horse power, regardless of actual power consumption.

Another factor favorable to manufactories is low labor cost and low labor turn-over. The working people are above the average intelligence of Central Americans, due to the comparative freedom from racial mixtures. Any number of young men and women can be had for one dollar gold per day. There was an attempt at organizing labor a few years ago, but what few factory hands there were, were so much better paid than farm labor that the movement failed absolutely.

Furthermore the natives are not in the habit of moving from place to place. Transportation is scarce and for them expensive. The home is a very steadying factor in the lives of these people, and tends to keep the family in one locality for generations.

Another attractive feature of Costa Rica is the freedom of manufactories from taxation. The government is so anxious to develop the industrial possibilities of the country that any one with a real business proposition can obtain a concession for a period of years which may not only give him freedom from taxation, but may permit export of product or import of raw materials free of duty.

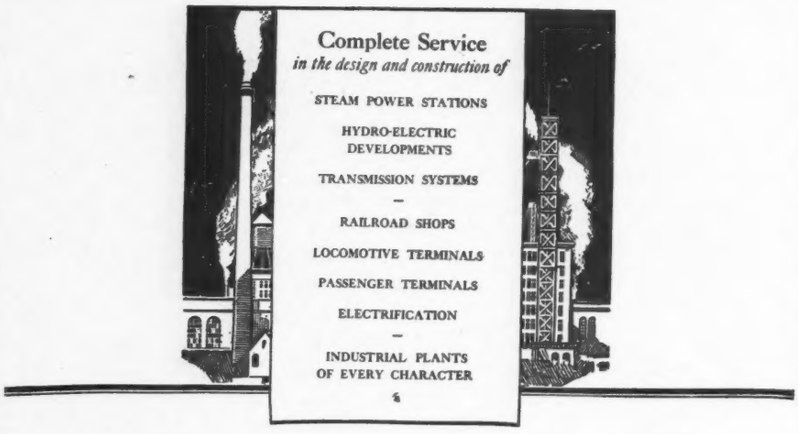
Power and Communications

The unlimited water power possibilities of Costa Rica cannot be over emphasized. Three miles below San José on the Tiribi River there is one power station of the Costa Rica Power and Light Company. This station is equipped with two 300 and one 150 K. V. A. generators and the other station fourteen miles from the city on the Virlla River has four 500 K. V. A. units. The power is generated at 2,300 volts, 60 cycles, stepped up for transmission to 17,000 and served to the city at 110 volts. Although these units are well loaded at present they are capable of producing another 1,000 K. W.

The Alvarado Telephone Company has two 1,150 K. V. A. units which also serve the city.

There are no steam auxiliary plants except a small direct current oil burning plant at Port Limón on the Carribbean Coast.

(*Continued on page 128*)



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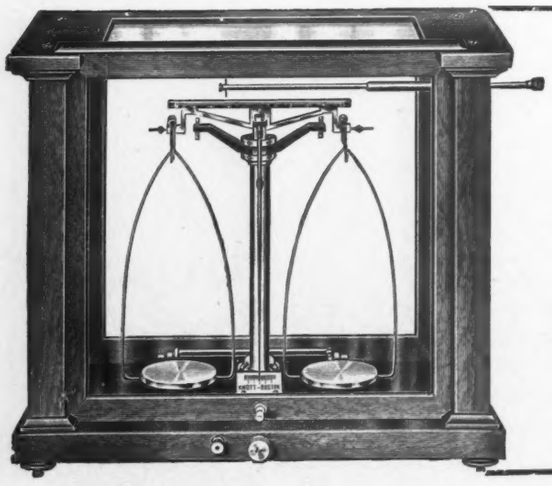

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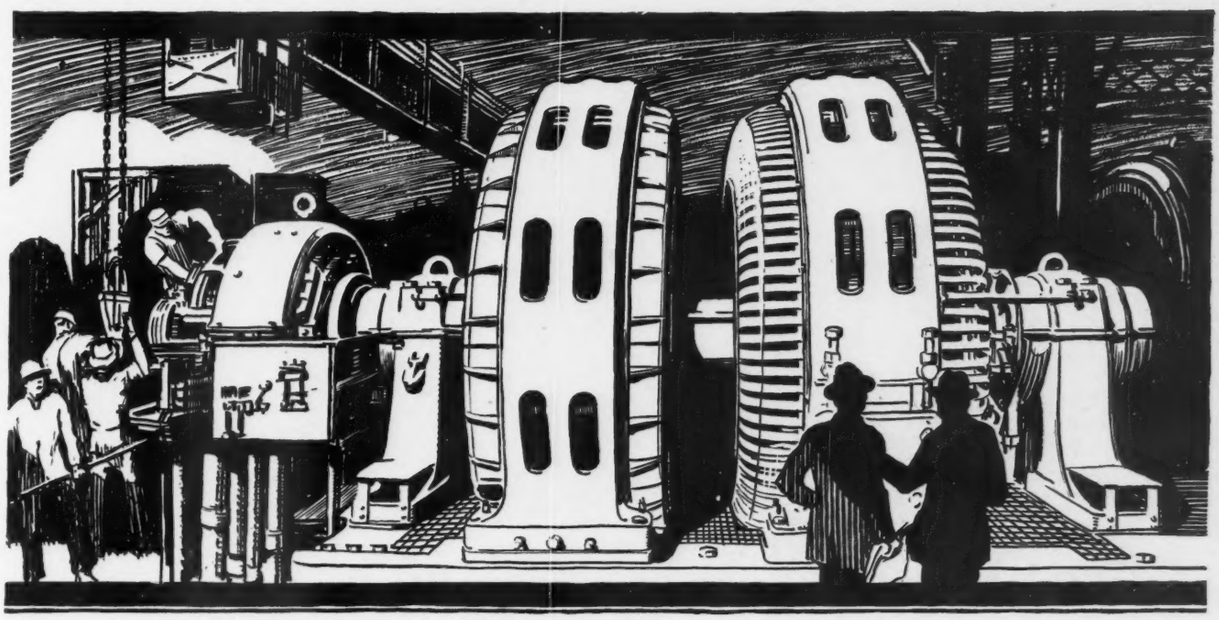

Real Service Must Be Engineered

Many of the men whose names are writ large in engineering history are design engineers; men like Westinghouse, Lamme, Stanley, Hodgkinson, Tesla, Shallenberger. Their inventions have the quality of usefulness, of reliability, of productability; which is an involved way, perhaps, of saying that they have the primary requisite of all really great inventions: *Serviceability.*

Engineering history abounds in instances of near-genius that produced no product, and of great developments that never reached completion; and most of these instances are explained by the lack, somewhere in the system, of that ability to give real Service.

Service, in a machine or a system, or wherever you find it, is not there by accident but because it was incorporated by men who understood what was required and knew how to provide it.

Much more is required of the designer than facility in calculation and mastery of theory. He must have first hand and thorough familiarity with manufacturing operations and with commercial and operating conditions. It takes more than mere ingenuity and inventiveness to design apparatus that will be really serviceable and will "stay put."

The design engineer, in the Westinghouse plan, is responsible for the performance of the finished product. He cannot possibly have the proper understanding of operation unless he operates and tests, unless he spends time and thought in investigation and study, not in the laboratory or drawing room, but right on the operating job. Here, most of his ideas will develop; and here he will see and prepare for all the different things which the product will later have to encounter. Then when he comes to put his creations on paper, his calculations will be necessary and helpful to check the conclusions which he has reached, and this right use of them requires training and a high degree of understanding. This proper balance of the physical and mathematical conception of things is what constitutes engineering judgement.

It should be thoroughly understood that the primary function of the design engineer is the conception and the production of new or improved apparatus, and familiarity with the practical is essential to the proper discharge of this duty.

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A SURVEY OF COSTA RICA

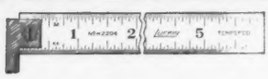
(Continued from page 126)

There are three other stations in Costa Rica of about the same size as the first two mentioned. They are at San Ramon, Miramar and Abangarez. These plants supply the stamp mills at the gold mines in the province of Guanacaste in the mountainous northwest section of Costa Rica. The Costa Rica Power and Light Company operates a nine mile single line turnout street railway in and around San José. They have sixteen cars and do all of their own repairs and even build some of their own cars. The fare is two tickets for twenty-five centimos which in American money would be about three cents a ride.

The meanest hovel in the city is equipped with electricity at the ridiculous rate of one colon, or twenty cents, per light per month, regardless of use. As stated before, there are no meters even on power machinery. The General Manager of the Power Company, Mr. Theodore Zinc, says that in view of the absence of any specific laws regarding theft, a meter could be "bridged" and the company could do nothing but remove the service, hence an expensive meter installation would be worthless.

Wireless equipment is very limited. The United Fruit Company maintains a station at Port Limon which receives the daily news for telegraphic transmission to the government at San José. This news is then distributed to the newspapers. The eastern half of the interoceanic railway, 110 miles, is operated by the Minor C. Keith interests. It was begun by the government and completed by Mr. Keith about 1888. The Pacific line of about sixty miles is owned and operated by the government. With the exception of a few spur lines, these are the only railways of any consequence.

Radio Sounding Device. Dr. Harvey C. Hayes, Physicist of the Naval Engineering Station at Annapolis, has designed a new apparatus which is a radio sounding device for registering ocean depths.



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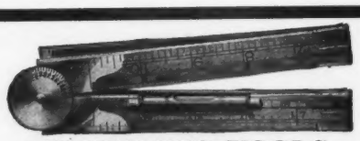

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The beginner will want this little volume for study, and the expert will use it for reference. "No endeavor is made," the author tells us in a brief preface, "to supply information on the theory of Radio, but this book is offered as a volume of practical information on modern radio instruments, their purchase, installation and operation."

The first chapter covers modern radio instruments, giving each separate type of instrument, their conventional symbols used in drawings, hook-ups and blue prints, with a brief description of each instrument and its functions, thus affording a key which unlocks the mysteries of technical articles in radio magazines and textbooks. Then follows a glossary of terms, and chapters on wiring diagrams, antennæ and grounds, receiving set costs and installation and use of receiving set. The last chapter tells how to construct a 5-watt radiophone.

The book is well and profusely illustrated, with a most comfortable arrangement of description opposite each clean cut drawing. Mr. Wood has managed to store a wealth of information in a book small enough to fit into a man's pocket. His English is clear, concise and directly to the point, so that the veriest beginner knows whereof the author speaks. And, because Mr. Wood has here displayed the rare "genius of common sense," many an expert will find much of value in this small but comprehensive encyclopedia.

THIS BOOK CONTAINS seven complete chapters of reliable, authoritative and instructive information which covers the entire scope of elementary Radio, from an "A B C" beginning to a practical knowledge of this fascinating subject.

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LUBRICATION

(*Continued from page 118*)

expected since this increases the rate of shear in the fluid film) and to lower the critical point; (*b*) softer bearing metals and smaller clearances tend to lower the critical point (see Fig. 3); (*c*) a low ratio of length to diameter tends to give a high critical point and somewhat raise the slope of the curve; and (*d*) oil grooves in the pressure side of the bearing tend to give curves convex upwards and abnormally high coefficients in the operating range.

Considerable light has also been thrown on the mysterious "oiliness" property in which lubricants are supposed to vary, and which affords so much scope for the oil salesman's imagination. It appears certain from results available that the value of f for a given $\frac{zn}{p}$ is independent of the lubricant (and indeed is the same as for non-lubricants) in the region of fluid film lubrication where practically all bearings normally operate. In other words, the viscosity of the fluid is its only essential property as far as the coefficient of friction in the region of perfect lubrication is concerned. The ordinary "oil testing" machines, on which so many measurements are made, almost invariably operate in this region (to prevent wear and changes in the surfaces) and are therefore nothing more nor less than very crude viscosimeters and tell nothing about the properties of an oil which is not more accurately measured by determining the viscosity as a function of temperature.

When, however, we approach the region of partial lubrication, marked differences between oils do appear, apparently due to the building up of an adsorbed semi-solid film on the metal surfaces. Not only does a lubricant with a high degree of "oiliness" give lower coefficients at starting and at very slow speeds, but it appears (data very inadequate as yet) to lower the critical point. If it

(*Continued on page 132*)

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SAMSON CORDAGE WORKS — **88 Broad Street, Boston 9, Mass.**

BETTER LIGHTING NEEDED IN INDUSTRIAL PLANTS.

In a paper read before the Illuminating Engineering Society, February, 1920, entitled, "A Survey of Industrial Lighting in Fifteen States," R. O. Eastman submitted some very interesting data regarding the lighting conditions in industrial institutions. The survey comprises some 446 institutions, in which lighting was considered by 55.4% as being vitally important, and by 31.6% as being moderately important, and by 13% as being of little importance. Practically 58% considered that lighting was as important as power in the operation of the plant, and a small proportion would give more attention to lighting than to anything else.

In considering the present condition of lighting as found in the various plants, only 9% ranked as excellent, about ⅓ ranked as good, 29% fair, 18.8% poor, 3.5% very poor, and 7.8% partly good and partly poor. It was found that the lighting in the offices was far superior to that in the shops; 19% being excellent, 36% good, 31% fair, and only 13% poor and none very poor.

On consulting the executives regarding what factors were most important in considering lighting, the following facts were revealed: Increase of production 79.4%, decrease of spoilage 71.1%, prevention of accidents 59.5%, improvement of good discipline 51.2%, and improvement of hygienic conditions 41.4%. Manufacturers who have good lighting appreciated its value largely from the standpoint of its stimulating effect upon output.

There is no question that any intelligent man who carefully considers the necessity for good lighting in an industrial plant, will agree that it is impossible for a person to do as good work, either in quality or quantity, in poor light as in good light, but yet the result of a careful analysis discloses the fact that only about 40% of industrial plants are furnishing good light to their workers and 60% are operating under poor lighting. It is hard to understand why such a proportion of concerns can be satisfied with a condition which is universally admitted to be a curtailer of efficiency and a prolific causer of accidents. The principal cause of this condition is that those in charge of such establishments have not given the attention to lighting that it demands. They do not know what constitutes good lighting, and in their absorbing interest of other factors of production have overlooked a vital one.

Every safety official should deeply interest himself in the lighting of his plant and insist upon good lighting as much as good goggles, good guards and other necessary accident prevention equipment. Every production manager should insist upon good lighting because the efficiency of the working force is increased by the condition of the lighting furnished. The plant physician should examine the lighting, for eye strain and eye fatigue are directly affected by poor lighting, as is the hygienic condition. Well lighted plants are invariably cleaner than poor lighted places. Plants equipped with Factrolite Glass in all windows are well lighted.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

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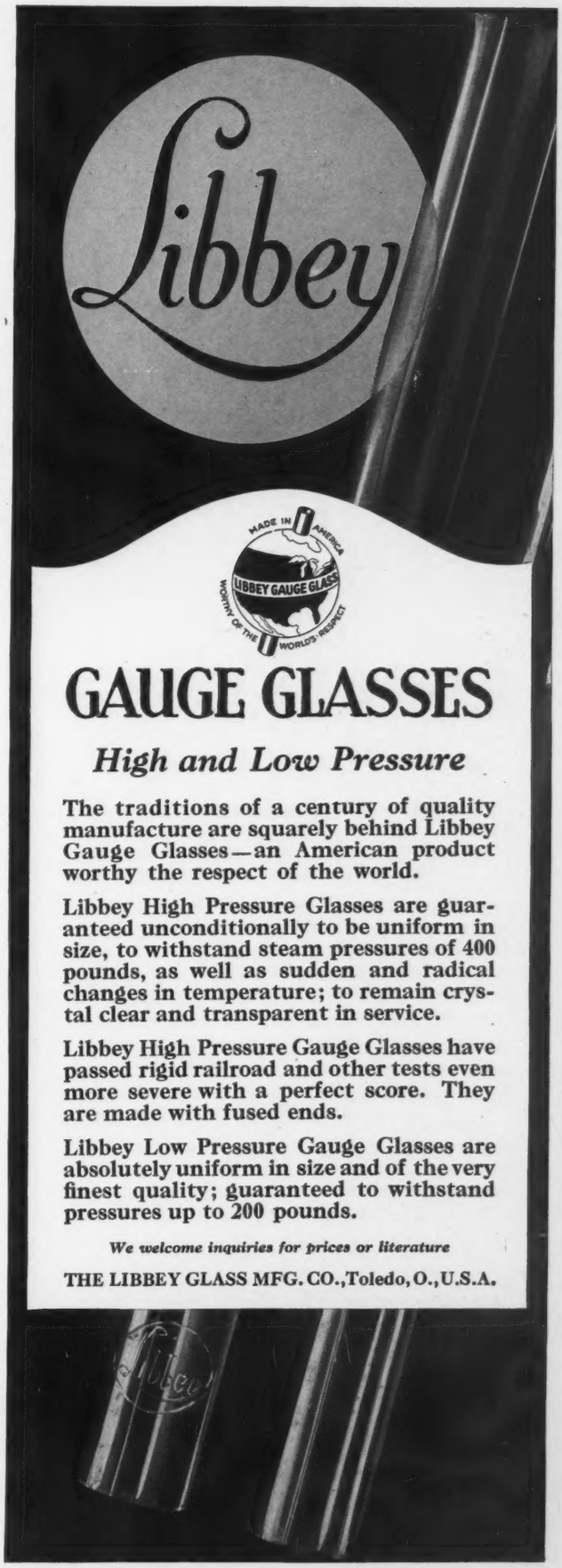
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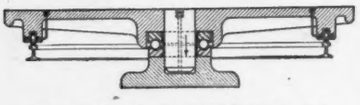

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Established 1871 **BOSTON, MASS.**

LUBRICATION

(*Continued from page 130*)

accomplishes the latter, a lubricant with high oiliness will permit operation at a lower value of $\frac{zn}{p}$, and hence indirectly lower the operating coefficient of friction, as well as decreasing abrasion at slow speeds, lowering the starting coefficient, etc.

In the light of these facts, the importance of measuring this property of "oiliness" in some definite way, of determining the mechanism of adsorbed film formation, and of the causes for the variation between different lubricants, becomes of prime importance.

An abstract of the results obtained by this laboratory along these lines will be presented in an early issue.

BOOK REVIEWS

(*Continued from page 115*)

At the Institute, at least, there appears to have been a need for such a book as this to enable the undergraduates to make use of the short cuts in algebraic calculations made possible by a knowledge of determinants. It seems certain that this publication will be well received by electrical students at Technology.

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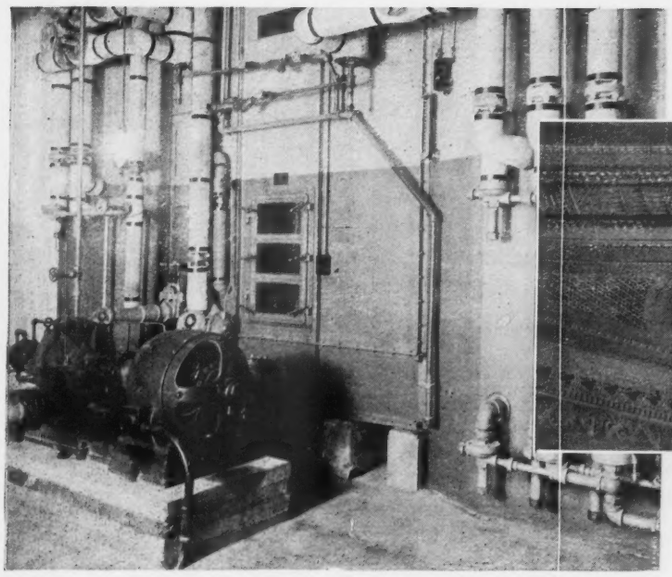
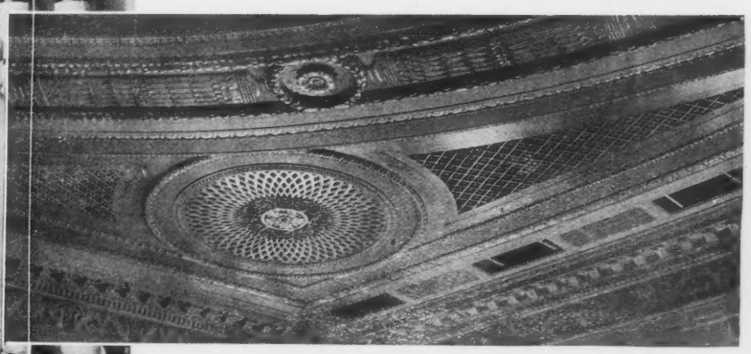


Sturtevant Air Washer with Pump directly connected to a Sturtevant Motor



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The owners, engineers, and architects, following the policy of having only the finest equipment in this building, installed Sturtevant Heating and Ventilating Systems throughout.

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Sturtevant engineers are always ready to coöperate with owners, architects, and engineers on Heating and Ventilating Systems for theatres or any other type of buildings.

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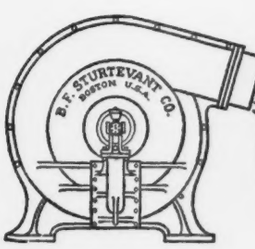

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